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Effect of different levels nitrogen and phosphorus fertilization on yield and chemical composition hybrid sunflower grown under irrigated condition

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Abstract: Optimum management of fertilizer is one of the most important components in producing maximum yield and profits in sunflower. This study was carried out during winter growing season of 2012 to investigate the effect of different levels of nitrogen (N), phosphorus (P) on growth yield and chemical components of sunflower (*Helianthus annuus L.*) hybrid under irrigated condition of Nile delta. Three levels of N (0, 40 and 80 kg ha^{-1}); in form of urea and three P levels (0, 50 and 100 kg ha^{-1}) in the form of triple super phosphate were applied as experimental treatments. The experiment was designed in split-plot arrangement with four replications. The N treatments were allotted in the main experimental plots while P was placed in subplots. Data regarding various growth parameters, yield components and chemical composition were measured for each experimental unit. The results revealed that the nitrogen significantly affected growth and yield parameters except shelling percentage and 100-seed weight; however, different N levels could not produce significant effect on the time to 50% flowering and chemical composition. Phosphorus had no significant effects on head diameter, shelling percentage and 100-seed weight, but it had no effect on days to 50% flowering and chemical composition. The interaction between N and P had significant effect on most of the growth parameters and all yield parameters.
Key words: *Helianthus annuus*, nitrogen, oil content, phosphorus, protein content.

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1. Introduction

Sunflower (*Helianthus annuus L.*) is a member of the family composite. In Sudan, sunflower emerged recently as an important cash crop, to strengthen the economy and to fill the gap in vegetable oil production for domestic consumption. Moreover, sunflower provides a high value livestock feed in addition to the fact that the oil extracted from its seeds is used as a raw material for manufacturing of paints and cosmetics. Accordingly, the area under sunflower has increased tremendously during last few years (Ali, 1989). The production of sunflower increased from 44000 tons to 73000 tons in 2007 by rate of 65.9% due to 85.1% increase in area under cultivation from i.e., from 36250 to 67083 ha. Sudan's contribution to the world gross sunflower production in 2004 was only about 0.045% that is possibly due to the fact that most of the sunflower production in Sudan was produced under rainfed condition (Abdul *et al*. 2000). Sunflower is better adapted to regions of prolonged drought, because of its ability to extract stored soil water in the deeper soil profile.

Sunflower has well-developed and branched root system, and maintains open stomata under condition of high evaporation demands that usually prevail in hot arid and semi arid regions. Judicious and timely application of fertilizers at critical growth stages of sunflower can increase its yield considerably. Several studies showed the positive response of sunflower to fertilization under irrigation and rainfed conditions in the central clay plains of Sudan (Elhassan *et al*., 2006; Lotfie and Salah, 2013). Others studies indicated that increase in growth and yield of sunflower and other crops is dependent upon the adequate supply of nitrogen (Ali, *et al*., 2004) and phosphorus (Weiss, 1983), and their ratio (Bi et al., 2013) because these nutrients regulate growth and photosynthesis. The agronomic practices such as adoption of type, amount of fertilizer and combination between nutrients are important factors that determine quality and yield in sunflower. Therefore, the objective of this study is to investigate the effect of different levels of nitrogenous and phosphatic fertilizer and their combination on growth and yield of sunflower under irrigated condition of Sudan.

2. Material and Methods

2.1 Site Description

The study was conducted in the Demonstration farm of the Faculty of Agriculture, University of Khartoum, Sudan, (Late. 15° 40'N, long. 32° 32'E) during the winter season 2012. Experimental site is located in the semi-arid region with very hot summer and a short rainy season during the months of July to October. The soil at experiment site is clayey with

low permeability and organic matter, very low nitrogen contents and basic pH (Table 1).

2.2 Layout and treatments

The experiment was laid out in split-plot design with four replications. The treatments consisted of three levels of nitrogen (N) namely N_0 (0 kg ha^{-1}), N_1 (40 kg ha^{-1}) and N_2 (80 kg ha^{-1}) and three levels of phosphorus P_0 (0 kg ha^{-1}), P_1 (50 kg ha^{-1}) and P_2 (100 kg ha^{-1}). The N levels were assigned to the main plots whereas P levels were allotted to the sub-plots. Urea and triple superphosphate were used as sources of N and P, respectively. The land was prepared by disc plowing followed by harrowing and leveling ridges were made at 70 cm spacing. The individual plot size was 4×5m consisting of five ridges each of three meters length. Sowing was done manually on the shoulder of the ridge on July 5th 2012. Sunflower hybrid "Panar" was used as experimental material. Seeds were sown at a rate of 4 seeds per hole at spacing 30 cm. The first irrigation was given immediately after sowing, and subsequent irrigation at 10-days interval. Standard crop protection measures were adapted including weeding to ensure stress free conditions throughout the sowing season except treatments described above.

Table 1. Soil physio-chemical characteristics

Soil parameters	Value
Physical analysis	
Sand %	34
Silt %	19
Clay %	48
Textural class	Clayey soil
Bulk density (gm/cm^3)	1.46
Water holding capacity (mm/m)	27
Chemical Analysis	
Total N (%)	0.05
P (mg/l)	3.43
K (mmol/L)	0.11
Organic matter %	1.2
pH	7.5

2.3 Data Collection

Vegetative parameters such as plant height, shoot dry weight and leaf area index (LAI) were measured at 25, 45 and 75 days after sowing by randomly harvesting three plants from the outer two ridges of each experimental unit. Plant height (cm), was measured from base of the stem to the tip of the youngest leaf. After harvesting each plant, root and shoot were separated and shoots oven dried at 80°C for 48 hours to measure shoot dry weight (g). At flowering five leaves from an area of 0.7 m^2 from each experimental unit were randomly selected to measure Leaf area index (LAI). Leaves were punched by using discs, and oven dried at 100°C for 24 hours then dry weights of punched leaves and discs were determined using sensitive balance, LAI was calculated as:

$$\text{Leaf area} = \frac{\text{dry weight of leavs} \times \text{area of discs}}{\text{dry weight of discs}} \quad (1)$$

. Data of days to 50% flowering i.e., days from sowing to the time when 50% of the plants had flowered was recorded from each experimental unit and used for further analysis.

After harvesting following yield components including; head diameter, number of seeds $head^{-1}$, weight of seeds $head^{-1}$ (g) and 100-Seed weight (g). Seed yield (t ha^{-1}) was determined by collecting seeds from an area of 0.7 m^2 form each experimental unit, and then calculated as:

$$\text{Seed yield (t/ha)} = \frac{\text{seed weight/plot (kg)} \times 10000}{\text{plot area} \times 1000} \quad (2)$$

Data regarding shelling percentage was calculated by equation 3:

$$\text{shelling \%} = \frac{\text{weight of seeds /head}}{\text{weight of head+seeds}} \times 100 \quad (3)$$

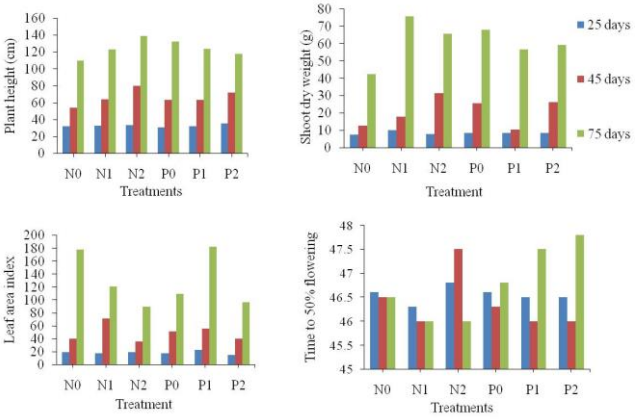

Fig.1: Effect of Nitrogen and Phosphorus application on plant height, shoot dry weight, leaf area index and time to 50% flowering.

2.3 Chemical analysis

The percentage oil content in seed was determined by Soxhlet extraction method using the following equation:

$$\text{Oil content \%} = \frac{\text{weight of extracted oil (g)}}{\text{weight of sample (g)}} \times 100 \quad (4)$$

In order to determine protein content, 10 grams of seeds were randomly collected from the yield of each plot and used for the determination by the micro-Kjeldahl method (Alimohammadi and Azizov, 2011). One gram of seed was taken from yield each plot and used for the determination of phosphorous content %

using the molybdenum blue method as described by Chapman and Pratt, (1961).

Data were analyzed using the statistical package for the social sciences (SPSS) and means were separated using least significant difference (LSD) as described by Gomez and Gomez, (1984). Differences were considered to be significant at the $p < 0.05$ level.

3. Results

3.1 Vegetative growth

Plant height was significantly influenced by N application, and increased with increasing N rate. Fig 1 showed that the N_2 (80 kg N ha^{-1}) resulted in an increased plant height at all stages, but the effect was more pronounced at 75 days after sowing which produced a plant height 138.9 cm. In case of phosphorus treatments, P_2 (100 kg ha^{-1}) showed greater plant height than other phosphorus levels at 25 and 45 days, but it was significant at 25 days only. The combination of N_2P_2 was significantly increased plant height, giving the higher value (41.3 cm) at 25 days (Fig 2).

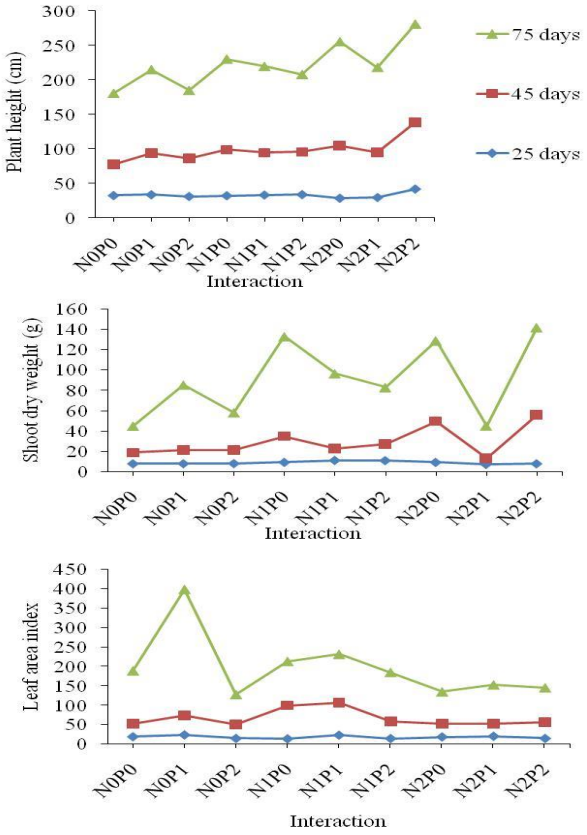

Fig.2: Interaction effect of Nitrogen and Phosphorus on plant height, shoot dry weight and leaf area index of sunflower.

The results regarding shoot dry weight (SDW) showed that, at 25 days, N_1 (40kg N ha^{-1}) was significantly increased the SDW over the control, while at 45-days after sowing N_2 significantly increased SDW than other N levels. At 75 days both nitrogen levels (N_1 and N_2 75.9 and 65.7 g, respectively) had significantly increased SDW comparing to control (Fig 1).

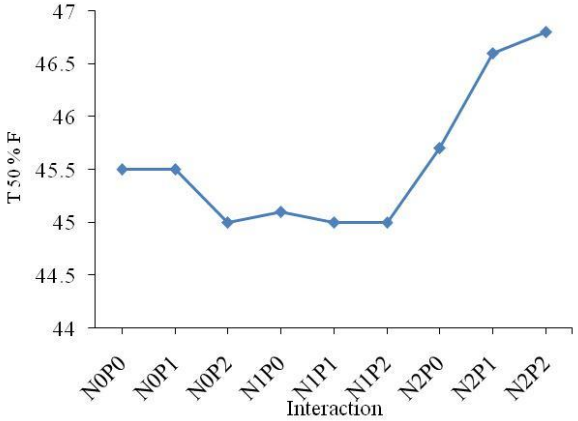

Fig.3: Effect of Nitrogen and Phosphorus application on time to 50% flowering of sunflower.

The effect of phosphorus on SDW was inconsistent. At 25 days P_2 gave a slight increase in SDW than other phosphorus levels. At both 45 and 75 days after sowing, P_1 produced significantly lower SDW than other phosphorus levels. The combination between N and P showed significant increased on SDW at all stages, specifically N_1P_1, N_2P_2 and N_1P_0 where the combinations produced the highest SDW at 25, 45 and 75 days after sowing (10.7, 48.4 and 98.3 g), respectively (Fig 2).

As shown in Fig 1, the lowest leaf area index (LAI) was produced by addition of N_2. At 45 days after sowing, N_1 application caused significant increase in LAI than other N levels. At 75 days after sowing, both N_1 and N_2 levels caused a substantial and significant reduction in LAI in comparison to the control (120.8, 89.5) respectively. As for P treatments, P_1 increased LAI at all stages, but the significant effect occurred at 25 and 75 days after sowing. At 45 days after sowing, P_2 gave significantly low LAI than the control. The combination of N and P had significant increasing effect on LAI at 45 and 75 days after sowing, where the combinations N_1P_0 and N_0P_1 (85.9, 323.7) respectively gave the highest LAI as compared to other combinations (Fig 2).

3.2 Reproductive parameters

The results showed that there were no significant differences among nitrogen for time to 50% flowering (Fig 1). On the hand, P application at all levels revealed also no significant differences. The data on the interactive effect of nitrogen and phosphorus have

showed no significant effect there have been presented in the (Fig 3)

3.3 Yield parameters

Data in Fig 4 showed that N_2 had significant effect on increased head diameter. Neither P treatments nor combination of N and P had any significant effect on head diameter (Fig 5 A).

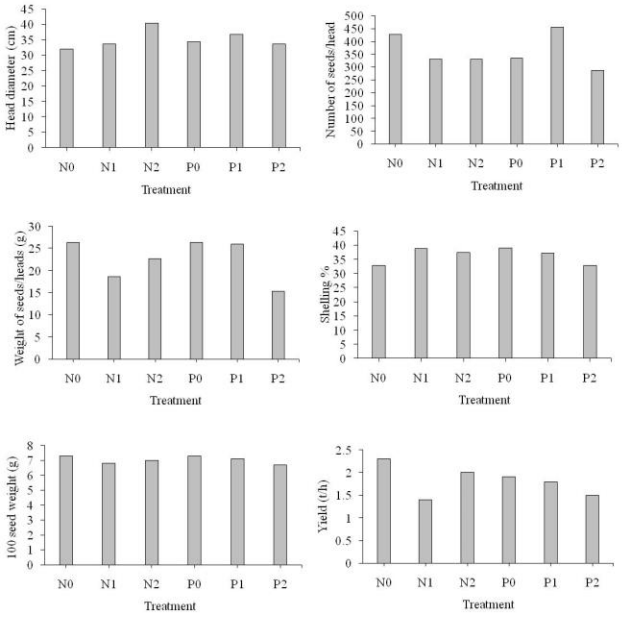

Fig.4: Effect of Nitrogen and Phosphorus on yield parameters of sunflower.

Results in Fig 4 showed that, addition of N_1 and N_2 significantly reduced the number of seeds/head in comparison to control. Among the P treatments, P_1 gave significantly higher number of seeds head^{-1} than other P levels, while P_2 gave the lowest value. The combination of N and P had significant effect on number of seeds head^{-1} with the combination N_2P_1 giving the highest value of 566.0 seeds head^{-1} (Fig 5 B).

Weight of seeds head^{-1} was reduced with N application, the reduction being significant at rate of N_1 (Fig 4). Meanwhile, P tended to reduce seed weight head^{-1}, the reduction being significant at P_2. The combination effects of N and P on weight of seeds head^{-1} were found to be significantly increased with N_0P_1 (30.8 g) (Fig 5 C).

The results in Fig 4 showed that N increased shelling %, but the effect was not significant. On the other hand, P treatments reduced shelling percentage, but the effect was also not significant. The combinations of N and P had no significant effect on shelling percentage (Fig 5 D).

The addition of nitrogen caused no change in the 100 seed weight. P treatments reduced100 seed weight, but the effect was not significant (Fig 4). Whereas there was no significant effect on 100 seed weight in the cause of N and P combination (Fig 5 E).

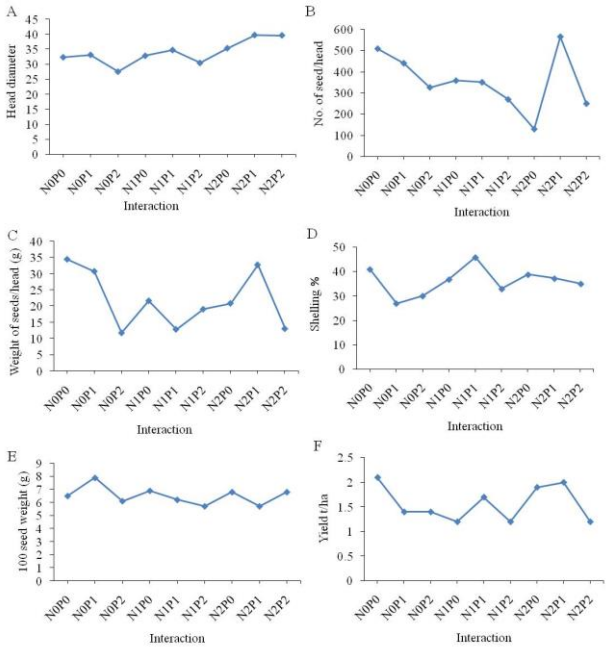

Fig. 5: Interaction effect of Nitrogen and Phosphorus on yield parameters of Sunflower.

Results demonstrated in Fig 4 showed, that nitrogen application had reduced final seed yield, the reduction being significant at N_1. Phosphorus also reduced seed yield, the reduction being significant at P_2. The other combination of N and P treatments produced near about the same seed yield without any significant change (Fig 5 F).

3.4 Chemical composition

The results in Fig 6 showed that N application either slightly increased oil content (N_1) or substantially reduced it (N_2), but the effect was insignificant. Phosphorus caused either a slight reduction (P_2) or an increase (P_1) in oil content, but the effect was insignificant. The combination of N and P had no significant effect on oil content (Fig 7).

The results in Fig 6 showed that N application caused an increase in the protein content over the control. For P it gave a slight increase (P_2) and a slight reduction (P_1) in seed protein content. The combination of N and P had no significant effect on protein content (Fig 7).

Addition of N_1 caused an increased in P content compared to other N levels (Fig 6). Phosphorus tended to reduce P content, but the effect was

insignificant. The combination of N and P had no significant effect on Phosphorus content (Fig 7).

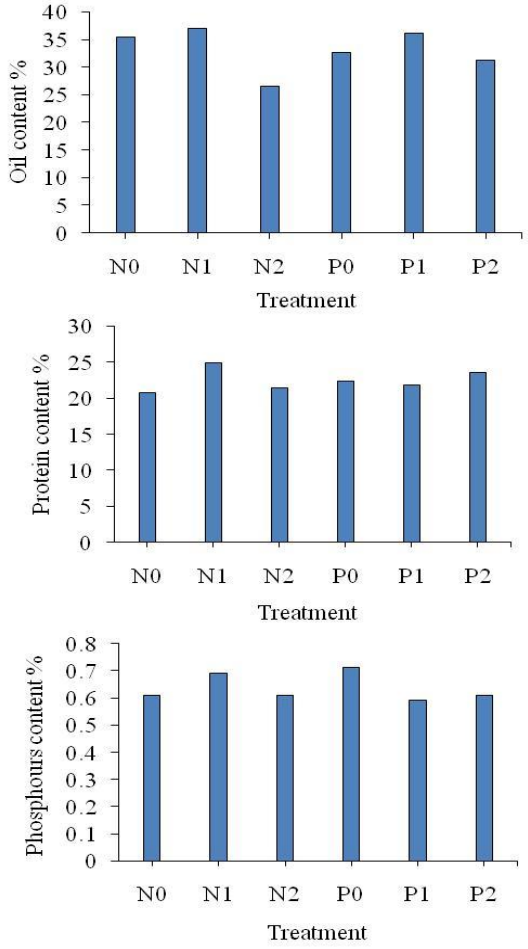

Fig.6: Effect of Nitrogen, Phosphorus on chemical parameters of sunflower.

4. DISCUSSION

Nitrogen (N) fertilizer had significant affect via improving vegetative growth led to increase on plant height; this could be due to the positive effect of N in stimulating vegetative growth, root growth and better absorption of other nutrients (Ali *et al*., 2004). Nitrogen is a constituent of the proteins, nucleic acids and nucleotides that are essential to the metabolic function of a plant. Similar results were obtained by other researches (Rani and Reddy, 1993; Martinez *et al*., 2010). Also, N fertilizer had significant affect on total dry weight per plant .This effect could be due to the positive effect of nitrogen on vegetative parameters due to increased growth rate through development of a large leaf area in the early stages (Teama and Mahmoud, 1994).

Leaf area per plant was significantly increased by N application. This may be due to the effect of N on leaf development. The results are in general agreement with the findings of Dahiphale and Pawar, (1993) that leaf area increased with N fertilization, an increase in nitrogen availability results in higher leaf production, this result in strong positive correlation between photosynthesis and leaf nitrogen content (Connor, *et al*., 2002). In contrast, N deprivation reduces the leaf production, individual leaf area and total leaf area (Vos *et al*., 1992; Toth *et al.*, 2002) resulting in a reduced area for light interception for photosynthesis.

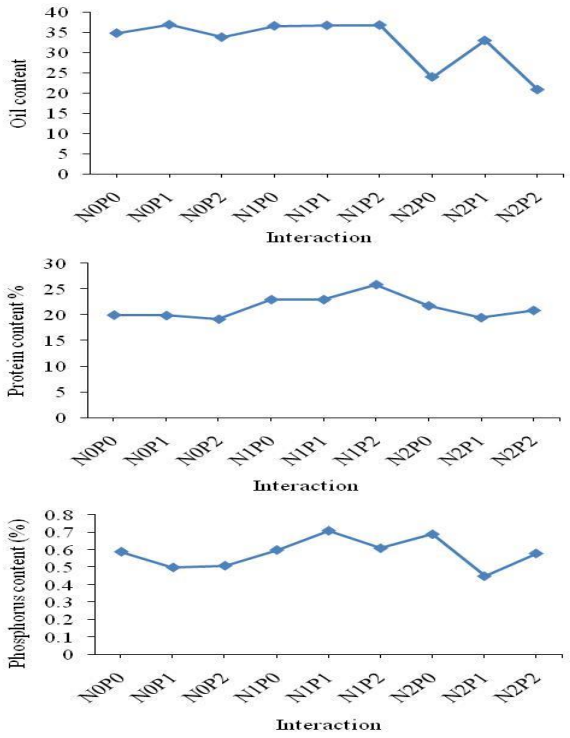

Fig. 7: Interactive effect of Nitrogen and Phosphorus on chemical composition of sunflower seed.

In this study the number of days to 50% flowering was shortened by nitrogen application. Similar results were obtained by Tomar *et al*., (1999) who indicated that flowering of sunflower was hastened by fertilizer application; which explains their responsiveness to fertilizer.

Head diameter (HD) is one of the most important yield components in sunflower plant; nitrogen fertilizer had significant effect on HD. Indeed, this effect could be associated with the general enhancement of vegetative growth in response to nitrogen contribution. Wajid *et al*., (2012) claimed that response of nitrogen fertilizer with different N levels on HD was highest with increasing nitrogen fertilizer.

The total number of seeds per head was significantly affected by nitrogen. This effect is

possibly due to the increase in HD resulting from nitrogen application. These results are in accordance with Steer *et al*., (1986) and Oyinlola *et al*., (2010).

Results regarding weight of seed head^{-1} had significantly increased effect by N fertilizer. This effect could be due to the role of nitrogen in increasing total dry matter production observed in this study. Nitrogen fertilizer had no significant affect on 100 seed weight. This result is in contrast with Kasem and El-Mesilhy, (1992) and Mohamed *et al*., (2003), whom reported increasing N levels caused increased seed yield of sunflower. It is possible that by increasing head diameter and number of seeds per head, N application resulted in production of smaller seeds.

Nitrogen fertilizer had no significant effect on shelling percentage. Although N enhanced vegetative growth and dry matter production as well as some yields components. It might not affected translocations of assimilates to seeds to the same degree. This result is in contrast with (Bader and Rashid, 1988).

Nitrogen fertilizer had inconsistent effect on final seed yield, this may be due to empty seeds or partially filled seeds appear to be dependent on various factors; nitrogen was suggested to be one of these factors (Sindagi, 1978). Also this effect could be due to the positive contribution of nitrogen on yield components, (HD, number of seeds head^{-1} and weight of seeds head^{-1}). In contrast with these findings, Özer *et al*., (2004) reported significant effects of N application on seed yield of the sunflower.

Results indicated that, the oil content was insignificantly affected by N application, this could be attributed to the a diluting effect of nitrogen on seed oil content due to increased number of seeds/head. Several researchers reported that, the oil content is reduced by N application (Khokani *et al*., 1993; Mojiri and Arzani, 2003). Nitrogen fertilizer had no significant effect on protein content. The same explanation offered for effect of nitrogen on oil content could hold true for this result. These results are supported with the findings of Singh *et al*., (1995).

In this study phosphorus application of fertilizer had a significant effect on all growth parameters except for plant height. This could be attributed to the fact that left over P favored the growth increased; similar observations were made by Hussain *et al*., (1998).

Number of days to 50% flowering was reduced by phosphorus application. Phosphorus is known to promote reproductive development in plants (Mohamed *et al*. 1993).

Phosphorus fertilizer had significant effect on some yield parameters such as number of seed/head, weight of seed/head and seed yield (t ha^{-1}), this confirm by Mohamed *et al*., (2003), who suggested that, seed yield of sunflower was significant increased with an increasing level of P. Such effects could be due to the impact of P on growth dry matter production and yield components of sunflower. Bahi *et al*., (1997) found that, grain yield was increased significantly with the application of P as a result of low available P in the soil.

Phosphorus (P) fertilizer had no significant effect on chemical composition; this associated with decrease on reproductive growth stage and decreased the seed oil content. Similar results were obtained by Maheswarappa *et al*., (1985) for oil content and protein content (Singh *et al*. 1977). However Weiss, (1983) reported that P significantly increased seed phosphorus content. Lack of P on seed chemical composition in this study could be attributed to low P availability in the alkaline clay soil of the experimental site, and that most of the P absorbed was utilized in growth and yield attributes, so that little P remained to affect seed chemical composition.

Combination of N and P with an optimum amount and ratio is very important and has greater effect on growth and yield of sunflower than the individual effect of any of these nutrients. Therefore, the combination of N and P had significant affect on the most of growth parameters except plant height. This effect might be due to the positive effect of nitrogen on growth which could have enhanced uptake and effect of phosphorus on plant growth. These findings were in line with the previous findings of Tahir, (1996) and Subhash *et al*., (2013).

5. CONCLUSION

The nitrogen utilization had significant effect on all growth and yield parameters except shelling percentage and 100-seed weight, but had no effect on the time to 50 % flowering and chemical composition. While Phosphorus application had significant effect on most growth parameters and yield parameters except head diameter, shelling percentage and 100-seed weight, but it had no effect on the 50% flowering and chemical composition. A progressive increase in yield and growth of sunflower was noticed with combination between N and P. Therefore, the availability of these elements can have a significant impact on the ultimate performance of the sunflower.

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Competing Interests

Authors must declare that they have no competing interests and commercial names and details of equipments are for the guidelines only.

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