INT. J. BIOL. BIOTECH., 14 (1): 101-107, 2017.

EFFECTS OF FERTILIZERS (N P K) ON GROWTH INDICES, YIELD AND QUALITY OF HYBRID SUNFLOWER

Muhammad Waqas[1], Ghazanfar Ullah[1], Abdul Aziz Khakwani[1], Ejaz Ahmad Khan[1], Kashif Waseem1 and Taseer Ahmed Khan[2]

[1]*Faculty of Agriculture, Gomal University, D. I. Khan, Khyber Pakhtunkhwa, Pakistan*
[2]*Department of Physiology, University of Karachi, Sindh, Pakistan*

ABSTRACT

An experiment was conducted to study the effects of different fertilizers doses of N, P and K on growth, yield and quality of hybrid sunflower at Agronomic Research Area, Faculty of Agriculture, Gomal University, Dera Ismail Khan during spring, 2011. An experiment was laid out in Randomized Complete Block Design (RCBD) by using four replications and ten treatments. The net plot size was kept as 3.6 m x 3 m (10.8 m^2). The treatments with different fertilizer levels were T_1= 50:30:10 NPK kg ha^{-1},T_2 = 50:30:20 NPK kg ha^{-1},T_3 = 50:30:30 NPK kg ha^{-1},T_4 = 100:60:30 NPK kg ha^{-1},T_5 = 100:60:40 NPK kg ha^{-1},T_6 = 100:60:50 NPK kg ha^{-1},T_7 = 150:90:40 NPK kg ha^{-1},T_8 = 150:90:50 NPK kg ha^{-1},T_9 = 150:90:60 NPK kg ha^{-1} and T_{10} (control) where no fertilizer were applied. All the growth and yield parameters were taken by using standard methods and analyzed statistically. Almost all the crop attributes including plant height, leaf area index, head diameter, number of achenes per head, 1000-achene weight, biological yield, grain yield and harvest index increased with increase in fertilizer levels except oil content. The results clearly revealed that highest achene yield (2955.5 kg ha^{-1}), biological yield (12857 kg ha^{-1}), 1000-achene weight (64.9 g), head diameter (31.1 cm), plant height (157.7 cm) were obtained by applying highest dose 150:90:60 NPK kg ha^{-1}. It is concluded from an experiment that the highest level of NPK (150:90:60 kg ha^{-1}) for hybrid sunflower is recommended under the agro-climatic conditions of Dera Ismail Khan.

Key words: *Helianthus annuus*, NPK levels, yield, oil contents.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) was first introduced in Pakistan as an oilseed crop in 1960's. Sunflower is the short duration, quick growing crop and has the potential to produce high quality of grains per unit area. Its area in Pakistan is 506,000 hectare with production of 755,000 tons and average achene yield of 1.6 tones per hectare (Anonymous, 2009). Sunflower ranks fourth in oil seed crop cultivated in the world (Fagundes *et al*., 2007). In Pakistan, sunflower has an important place as an oilseed crop. It has shown its potential to contribute its share in domestic edible oil requirements. It has lion's share (34.1 g) in per capita vegetable oil consumption of daily oil intake (83 g) in our country (Anonymous, 2009). Pakistan is bestowed with various ecologies where sunflower can be cultivated because of its wide range of adaptability.

Sunflower hybrids available in Pakistani markets exhibited diversity in their response to cultivation area. These hybrids, because of difference in their root system and penetration capacity, vary in their response to protein and oil contents in achene (Omidi *et al*., 2010). Sunflower cooking oil is extensively used by heart patients because of very low cholesterol concentration and high fatty acid concentration (Flagella *et al*., 2002; Omidi *et al*., 2010). In oilseeds crops, production of sunflower increases approximately 1.8 times in world market during the last 20 years (Pouzet and Delpancke, 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). Enhancement in fertilizer directly influences the yield of sunflower through augmenting its yield components (Ali *et al*., 2012). In organic fertilizer especially major nutrients (N, P and K) can significantly boast up the physiological and yield attributes of sunflower (Kho, 2000; Parsad *et al*., 2002; Cechin and Fumis, 2004 and Sadras, 2006).

Nitrogen, phosphorous and potash (NPK) ratio is also an important indicator in crop production that identifies balanced or unbalanced fertilization. Application of nitrogenous, phosphatic and potash fertilizer above or below the optimum level adversely affects the growth and yield. Malik *et al*. (2006) stated that various combinations of NPK had profound impact on achene yield of sunflower.

Nitrogen fertilizer application increases cost of production more than any other nutrient (Aslam *et al*. 2011), however, Nitrogen is considered necessary element for plant kingdom and growth processes in crops (Laegreid, 1999) and has fundamental importance for plants but its availability in the soil is in low concentration (Tisdale *et al*., 2003). Malligawad *et al*. (2004) conveyed that 100 kg N ha^{-1} proved useful dose for obtaining bumper crop yield of

Corresponding Author: Ghazanfar Ullah , Faculty of Agriculture, Gomal University, Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan.

sunflower. Similarly, nitrogen fertilizer enhances crop growth indices, yield and quality attributes. Abdalla *et al*., 2013). Anyhow, its efficacy depends upon its presence in the soil and prevailing agro-climatic conditions (Laureti *et al*., 2007).

Phosphorous ranks 2nd to nitrogen in its role for crop growth and development. Plant community desire optimum phosphorus from its very early stage to sustain efficient production of crops (Grant *et al*., 2005). Amongst different crop management practices, P usage contributes substantially in crop yield increment (Alam *et al*., 2003). Phosphorous promotes root development, seed size and final grain yield of hybrid sunflower (Arif *et al*., 2003).

Potassium significance is not inferior to any other nutrient. Potassium uptake is more than or almost equal to nitrogen. Potassium is regarded as chief element in improvising the crop quality as well as drought resistance (Reddy, 2004). Significant jump in agronomic parameters specifically yield components of sunflower had shown encouraging results by incorporating potassium in fertilizer application program (Munir *et al*., 2007 and Iqbal *et al*., 2008).

Yield of a crop is continuously influenced by availability of nutrients which mostly includes nitrogen and phosphorus and potassium, while different management practices were approached for individual nutrients and also in integrated plant nutrient management (IPNM). On the basis of above mentioned facts, an experiment was conducted to see the effects of different doses of NPK on growth, yield and quality of hybrid sunflower. Therefore, it was planned to find out the best nutrient combination for obtaining maximum yield potential of sunflower hybrid 'Ausigold-61' under soil and agro-climatic conditions of Dera Ismail Khan.

MATERIALS AND METHODS

Soil analysis and weather data

This research was conducted at the agronomic research area of Faculty of Agriculture, Gomal University, D. I. Khan (Pakistan) during spring 2011. The soil organic matter was determined through wet oxidation based upon the Walkley and Black method (Nelson and Sommers, 1982). Total N in soil was determined by the Kjeldahl's method (Bremner and Mulvaney, 1982). Phosphorus was measured by spectrophotometer and potash by flame photometer. The extractable P and K in soil sample were determined by the AB-DTPA extractable method (Soltanpour, 1985).

Physico-chemical analysis indicated that soil was somewhat alkaline [pH 8.40, SAR 6.05 (meq/L)½ (Richards, 1954), ECe 2.72 dS/m Bulk density 1.31 g cm^{-3}], nitrogen (0.021 %), P 5.09 (mg kg^{-1}), Available K 121.8 (mg kg^{-1}), low in organic matter (0.43%) and the clay loam soil texture. Monthly weather data of 2011 depicted that the respective maximum/minimum temperatures were lowest in March 28/11 °C increasing towards April (34/16 °C) and highest at maturity in June (24/26 °C). Total rainfall (24 mm) during sunflower crop growth period remained deficient.

Procedure for experiment

Experimental field was laid out in randomized complete block design with four replications. Various NPK fertilizer levels were assigned to plots, with NPK doses of; T_1 (50:30:10), T_2 (50,30,20), T_3 (50:30:30), T_4 (100:60:30), T_5 (100:60:40), T_6 (100:60:50), T_7 (150:90:40), T_8 (150:90:50), T_9 (150:90:60) and T_{10} (Control). Sources of fertilizer were urea for N, single super phosphate for P and sulfate of potash for K. Entire dosage of phosphorus and potassium were applied as basal fertilizers during land preparation just before sunflower sowing. Nitrogen was applied in two split doses; initially before seed sowing and then at first irrigation through broadcast methods as per treatments plan. Sunflower variety 'Ausigold-61' was sown with recommended seed rate of 7 kg/ha. Size of sub-plots (for NPK levels treatments) was 3.6 x 3 m^2. Chemical herbicides were used to control the weeds in the experimental field. Dual Gold (S-metachlor) was pre plant incorporated @ 1.6 lit /ha to control different weeds in sunflower field.

Crop observations

In this trial attributes i.e., Plant height (cm), Leaf area index, Head diameter (cm), Number of achenes per head, 1000-seed weight (g), Biological yield (kg ha^{-1}), Achene yield (kg ha^{-1}), Harvest index (%) and Oil contents (%) [determined by Soxhelt fat extraction method (A.O.A.C, 1995)] were recorded.

Statistical analysis

Crop data on various parameters were analyzed statistically through MSTAT-C software by Fisher's analysis of variance technique and consequently LSD test was utilized for comparison of treatment means (Steel *et al*., 1997).

RESULTS AND DISCUSSION

Plant height (cm)

Plant height is the function of combined effects of genetic make-up and environment influences with nutritional status of the soil. Data presented in Table 1 revealed a significant difference in plant height of sunflower hybrid. NPK levels significantly influenced plant height. From the data the treatment T_9 fertilized with 150:90:60 kg ha^{-1} NPK gave maximum plant height (157.7 cm.) The minimum plant height (114.0 cm) was obtained from control treatment T_{10} where no NPK was applied. The value was significantly lower than other treatments. It is clear from the data that NPK at different levels significantly affected the plant height. High NPK doses extended growth period and thus increased plant height. Poonia (2000) and Siddiqui *et al*. (2009) also showed significant differences and enhanced plant height parameter.

Leaf Area Index (LAI)

The data shown in Table 1 revealed significant differences among the treatments. The data indicated that maximum leaf area index (LAI) 13.7 was recorded in T_9 (NPK 150:90:60 kg ha^{-1}), it was followed by T_8 (150:90:50 kg ha^{-1}) which produced 12.1 LAI. The minimum leaf area index 4.3 was recorded in T_{10} (control). The greater leaf expansion in sunflower hybrid could be attributed to high rate of cell division and cell enlargement as described by Bange *et al*. (2000) and Cechin and Fumis (2000). Ali *et al*. (2000) also observed significant effects of nitrogen and phosphorus on LAI of sunflower. Similar results are also corroborated by Bakht *et al*. (2010) who reported that LAI significantly increased with increase in fertilizers levels.

Head diameter (cm)

Size of head contributes substantially to achene yield of sunflower because it influences both number of achenes $head^{-1}$ and achene size. Table 1 depicted maximum head diameter (31.1 cm) which was produced by T_9 (150:90:60 NPK kg ha^{-1}) and minimum head size (10.6 cm) was recorded in the T_1 (control) treatment, where no NPK was applied. Production potential of sunflower is determined by the size of its head which is most important yield component. Inclusion of high rate of phosphorus and potassium in fertilizer combination increased the effectiveness of nitrogen which could be responsible for increased head diameter. The increase in head diameter may be due to increase in the ability of plant to increase their metabolic activities due to N-fertilization. The increase in N-rate is attributed to increase in head diameter. The improvement in the head diameter may be accredited to more vegetative growth due to fertilizer levels. Hakoomat *et al*. (2004) observed that head diameter is increased with the increase of NPK rates. Malik *et al*. (2004) and Naseem *et al*. (2011) also reported that head diameter of sunflower was increased by increasing level of N, P and K.

Number of achenes ($head^{-1}$)

The data given in Table 1 presented significant differences among the treatment means. It is clear from the data that highest number of achenes $head^{-1}$ (1335.5) was recorded in T_9 (150:90:60 kg ha^{-1}). It was followed by T_8, T_7 and T_6 which were statistically at par with each other. The lowest number of achenes $head^{-1}$ (423.5and 508.8) were recorded in T_1 and T_{10} respectively. Treatments T_4, T_5, T_3 and T_2 produced higher achenes $head^{-1}$ as compare to T_1 and T_{10} but were at par statistically with each other. The increase in the balanced dose of NPK increased the overall growth which in turn led to increase in photosynthetic activity and converted large number of photosynthates to the head, which ultimately enhanced head size and number of achenes in a single head. Sadiq *et al*. (2000) also advocated that NPK increased number of grains $head^{-1}$.

1000-achene weight (g)

Table 2 exhibited that various NPK doses had significant positive effect on 1000-achene weight and the highest weight (64.9 g) per 1000 achenes was recorded in T_9 (150:90:60 NPK kg ha^{-1}), while the minimum weight (42.7g) per 1000 achenes was recorded in T_1 (control) treatment, where no NPK was applied. Weight per 1000-achenes is a king pin in the formulation of final seed yield of sunflower. Arif *et al*. (2003) reported that by increasing NP levels, 1000-achene weight was increased who concluded that 160 kg N ha^{-1} and 90 kg P ha^{-1} was proper dose of N and P to get maximum 1000-achene weight. An increase in achene's weight of sunflower hybrids in response to N-fertilization as also been reported by Anwer-ul-Haq *et al*. (2006).

Biological yield (kg ha^{-1})

Biological yield is an important parameter to judge the photosynthetic activity of a crop. Table 2 indicated a significant difference in biological yield of sunflower hybrid. It is clear from the data that the maximum biological yield 12857 kg $ha^{-1}$was produced by T_9. It was followed by T_8 which produced 11203 kg ha^{-1}. The treatments T_6, T_5, T_3 and T_2 produced biological yield of 9630, 9455, 8826 and 8729 kg ha^{-1} correspondingly and were statistically par

with each other. The minimum biological yield 7107 kg ha^{-1} was recorded in T_{10} (control). Biological yield enhancement due to the increment of NPK up to a certain level might be due to efficient photosynthetic activity and nutrient uptake which in turn increased growth and development of sunflower. Soleymani *et al*. (2013) increased biomass yield by applying NPK fertilizer in their cropping scheme.

Table 1. Effect of different doses of NPK on Plant height (cm), Leaf area index, Head diameter and Number of achenes (head^{-1}) of sunflower.

Treatments	NPK (kg ha^{-1})	Plant height (cm)	Leaf area index	Head diameter (cm)	Number of achenes (head^{-1})
T_1	50:30:10	125.7 cd	6.8 h	14.8 h	508.8 d
T_2	50:30:20	142.7 bc	7.3 g	16.1 h	722.5 c
T_3	50:30:30	138.0 ab	7.7 f	17.6 g	758.8 c
T_4	100:60:30	154.0 ab	8.8 e	20.0 f	788.0 c
T_5	100:60:40	145.7 ab	9.6 d	22.1 e	840.8 c
T_6	100:60:50	142.7 ab	9.9 d	23.5 d	1016.0 b
T_7	150:90:40	144.7 ab	10.5 c	25.9 c	1091.8 b
T_8	150:90:50	153.5 ab	12.1 b	28.0 b	1157.0 b
T_9	150:90:60	157.7 a	13.7 a	31.1 a	1335.3 a
T_{10}	Control	114.0 d	4.3 i	10.6 i	423.5 d
$LSD_{0.05}$		16.04	0.27	1.31	154.6

Means followed by different letter(s) in a column are statistically significant at 5% level of probability.

Table 2. Effect of different doses of NPK on 1000-achene weight (g), Biological yield (kg ha^{-1}), Achene yield (kg ha^{-1}), Harvest index (%) and Oil content (%) of sunflower.

Treatments	NPK (kg ha^{-1})	1000 achene weight (g)	Biological yield (kg ha^{-1})	Achene yield (kg ha^{-1})	Harvest index (%)	Oil Content (%)
T_1	50:30:10	44.1 g	8397 g	1552.0 g	18.51 e	47.96 ^{NS}
T_2	50:30:20	47.8 f	8729 f	1627.3 f	18.64 de	48.93
T_3	50:30:30	50.3 e	8826 f	1698.3 f	19.24 cd	48.17
T_4	100:60:30	55.2 d	9157 e	1785.0 e	19.49 c	46.43
T_5	100:60:40	58.4 c	9455 d	1849.8 de	19.56 c	46.56
T_6	100:60:50	58.5 c	9630 d	1892.3 d	19.65 c	47.70
T_7	150:90:40	59.7 c	10569 c	2161.8 c	20.45 b	49.00
T_8	150:90:50	63.0 b	11023 b	2525.0 b	22.90 a	48.20
T_9	150:90:60	64.9 a	12857 a	2955.5 a	22.98 a	48.81
T_{10}	Control	42.7 g	7107 h	1283.8 h	18.07 e	49.56
$LSD_{0.05}$		1.57	296.14	73.72	0.676	--

Means followed by different letter(s) in a column are statistically significant at 5% level of probability.

Achene yield (kg ha^{-1})

Effect of different treatments on achene yield was predominant in Table 2. NPK levels also affected significantly achene yield. It was observed that highest achene yield (2955.5 kg ha^{-1}) was recorded in T_9 (150:90:60 NPK kg ha^{-1}) whereas the lowest achene yield (1283.8 kg ha^{-1}) was recorded in T_1 (control) treatment where no NPK was applied. Sunflower highest achene yield is due to more achenes head^{-1} and higher 1000-achene weight because these NPK levels proved to be ideal doses for the plants utilization and had contributed towards the promotion of yield components with a significant difference. Increase in achene yield is a requisite to ensure the desirable physiological conditions necessary for successful plant production. Ayyappan *et al*., (2002), Kardar *et al*.,

(2001) and Nawaz *et al*. (2003), Abbadi *et al*. (2008) and Osman and Ewed (2010) conveyed that nitrogen individually or in proper combination enhanced yield of sunflower in comparison to control.

Harvest index (%)

The harvest index represents the physiological competence of plants to change the fraction of photo-assimilates to grain yield. The data in Table 2, demonstrated that harvest index (H.I) significantly differed among different NPK doses. Maximum harvest index 22.98 and 22.90 % was recorded in T_9 (150:90:60 kg ha^{-1}) and T_8 (150:90:50 kg ha^{-1}) while the treatments T_4, T_5 and T_6 produced statistically similar harvest index 19.49, 19.56, 19.65 % to each other. The minimum harvest index 18.07 % was recorded in T_{10} (control). Increase in harvest index might be due to optimum supply of the NPK dose as we are well aware of their magnanimous role in vegetative and reproductive phase of the plant. Saleem and Malik (2004) also reported differences among the harvest index values in response to different fertilizer levels. The results are also in line with the work of (Thavaprakash *et al*., 2003).

Oil content (%)

The data in Table 2 disclosed that different levels of NPK had non-significant on oil content of sunflower. However, maximum oil content (49.56 %) was recorded in T_{10} where no fertilizer was applied. These findings are corroborated by Syed *et al*. (2003) and Abdel-Mortagally *et al*. (2010) who did not found positive influence of inorganic fertilizers on oil percentage of two sunflower hybrids.

Conclusion

From the given research work, it can be concluded that sunflower hybrid variety 'Ausigold-61' produced highest grain yield 2955.5 kg ha^{-1} from fertilizer combination level of NPK at 150:90:60 kg $ha^{-1}$and showed superiority over rest of the NPK combinations. Therefore, on the basis of their good performance, 150:90:60 kg ha^{-1} of NPK is recommended for general cultivation of sunflower hybrid in Dera Ismail Khan. Adaption of these NPK levels in D. I. Khan's ecology and similar environmental conditions prevailing in other parts of the country can play a pivotal role in increasing sunflower productivity.

REFERENCES

Abbadi, I., J. Gerendas and B. Sattelmacher (2008). Effects of nitrogen supply on growth, yield and yield components of safflower and sunflower. *Plant Soil*, 306:167-180.

Abdalla, A. S., M. E. Abdelgani and A. G. Osman (2013). Effects of biological and mineral fertilization on yield, chemical composition and physical characteristics of chickpea (*Cicer arietinum* L.) seeds. *Pak. J. Nutr*., 12: 1-7.

Abdel-Mortagally, F. M. F. and E. A. Osman (2010). Effect of nitrogen and potassium fertilization on productivity of two sunflower cultivars under east of El-ewinate conditions. *American-Eurasion J. Agric. and Environ. Sci*., 8: 397-401.

Alam, S. M., S. A. Shah and M. Akhter (2003). Varietal differences in wheat yield and phosphorus use efficiency as influenced by method of phosphorus application. *Songklanakarin J. Sci. Tech*., 25: 175-181.

Ali, A., A. Ahmad, T. Khaliq and J. Akhtar (2012). Planting density and nitrogen rates optimization for growth and yield of sunflower (*Helianthus annuus* L.) hybrids. *Journal of Animal and Plant Sciences*, 22 (4):1070-1075.

Ali, M., S. K. Khalil and K. Nawab (2000). Response of sunflower hybrids to various levels of nitrogen and phosphorus. *Sarhad J. Agri*., 16(5):477-483.

Anonymous, (2009). *Economic Survey of Pakistan*, 2008-2009. Finance Division Economic Advisory Wing Islamabad Pakistan. pp, 22-23.

Anwar-ul-Haq, A., M. A. Rashid, M. A. Butt, M. Akhter, Aslam and A. Saeed (2006). Evaluation of sunflower (*Helianthus annuus* L.) hybrids for yield and yield components in central Punjab. *J. Agric. Res*., 44, 277-285.

A. O. A. C. (1995). *Association of Official Analytical Chemists. Official Methods of Analysis*, 16th Ed. AOAC International, Washington, D. C., USA.

Arif, M., K. M. Kakar and G. M. Kakar (2003). Response of sunflower to various levels of nitrogen and phosphorus. *J . Sci. Tech., Univ. Peshawar*, 27:63-66.

Aslam M., M.A. Khan, I.U. Awan, E.A. Khan, A.A. Khan and G. Jilani (2011). Effect of single and combined use of various organic amendments on wheat grown over green manured soil: I. Growth and yield attributes. *Pak. J. Nutr*., 10(7): 640-646.

Ayyappan, S., R. B. P. Kumar and M. Ganapathy (2002). Influence of levels of nitrogen on the yield and quality of sunflower. *Agric. Res*., 23: 317-318.

Bakht, J., M. Shafi, M. Yousaf and H.U. Shah (2010). Physiology, phenology and yield of sunflower (autumn) as affected by NPK fertilizer and hybrids. *Pak. J. Bot*., 42:1909-1922.

Bange, M. P., G.L. Hammer, S. P. Milroy and K. G. Rickert (2000). Improving estimates of individual leaf area of sunflower. *Agron. J*., 92 761-765.

Bremner, J. M. and C. S. Mulvaney (1982). Total nitrogen. In: *Methods of Soil Analysis.*(A.L. Page, R.H. Miller and D. R. Keeny Eds.), American Society of Agronomy and Soil Science Society of America, Madison. 1119-1123.

Cechin, I. and T. de. F. Fumis (2004). Effect of nitrogen supply on growth and photosynthesis of sunflower plants in the greenhouse. *Plant Sci*., 166: 1379-1385.

Fagundes, J., D. Santiago, G. Mello, A. M. deBellé, and N. A. Streck (2007). Growth, development and delay of leaf senescence in pot-grown sunflower (*Helianthus annuus* L.): sources and rates of nitrogen. *Ciência Rural*., 37(4):987-993.

Flagella, Z., T. Rotuuno, E. Tarantino, R. D. Caterina and A. D. Caro (2002). Changes in seed yield and oil fatty acid composition of high oleic sunflower (*Helianthus annuus* L.) hybrids in relation to the sowing date and the water regime. *Eurp. J. Agron*., 17:221-230.

Grant, C., S. Bittman, M. Montreal, C. Plenchette and C. Morel (2005). Soil and fertilizer phosphorus: Effect on plant P supply and mycorrhizal development. *Can. J. Plant Sci*., 85: 3-14.

Hakoomat Ali., S.A.Randhawa, and Muhammad Yousaf (2004). Effect of planting dates and nitrogen application on yield potential and oil contents of sunflower. *Indus J. Plant Sci*., 3(2):224-228.

Iqbal, J., B. Hussain, M. F. Saleem, M. A. Munir and M. Aslam (2008). Bio-economics of autumn planted sunflower (*Helianthus annuus* L.) hybrids under different NPK applications. *Pak. J. Agri. Sci*., 45(3): 19-24.

Kardar, I., D. Lukacs, J. Voros and J. Szilagyi (2001). Fertilization of sunflower (*Helianthus annuus* L.) on a calcareous loamy chernozem soil. *Novenythermeles*, 50: 297-308.

Kho, R. M. (2000). On crop production and the balance of available resources. *Agric. Ecosystem. Environ*., 80: 71-85.

Laegreid, M., O. Ch. Bockman and O. Kaarstad (1999). *Agriculture, fertilizers and the environment*. CABI Publishers, U.K., pp. 1-320.

Lauretti, D., S. Pieri, G. P. Vannozzi, M. Turi and R. Giovanardi (2007). Nitrogen fertilization in wet and dry climate. *Helia*., 30(47): 135-140.

Malik, M. A., M. F. Saleem and A. Rehman (2004). Suitable level of NPK for harvesting the maximum returns of sunflower (*Helianthus annuus* L.). *Int. J. Agri. Biol*., 6(2): 240-242.

Malik, M. A., M. F. Saleem, M. Sana and A. Rehman (2006). Suitable level of N, P and K for harvesting the maximum returns of sunflower. *Int. J. Agric. and Bio*., 6(2): 240-242.

Malligawad, L. H., K. G. Parameshwarappa and K. Giriraj (2004). Studies on the effect of ratios and level of NPK fertilizer nutrients of the productivity of hybrid sunflower under rainfed farming situations. *Proc. 16th Int. Sunflower Conference*, Fargo, ND, USA 1: 377-386.

Munir, M. A., M. A. Malik and M. F. Saleem (2007). Impact of integration of crop manuring and nitrogen application on growth, yield and quality of spring planted sunflower (*Helianthusannuus* L.). *Pak J. Botany*, 39(2): 441-449.

Naseem,W., A. Ahmad, A. Wajid, J. Akhtar and D. Muhammad (2011). Nitrogen effects on growth and development of sunflower hybrids under agro-climatic conditions of Multan. *Pak. J. Botany*, 43(4): 2083-2092.

Nawaz, N., G. Sarwar, M. Yousaf, T. Naseeb, A. Ahmed and M. J. Shah (2003). Yield and yield components of sunflower as affected by various NPK levels. *Asian J. Plant Sci*., 2(7): 561-562.

Nelson, D. W. and L. E. Sommers (1982). *Total carbon, organic carbon, and organic matter. Methods of Soil Analysis*, Part 2. ASA 9, 2nd edition.

Omidi, H., Z. Tahmasebi, H.A.N. Badi, H. Torabi and M. Miransari (2010). Fatty acid composition of canola as affected by agronomical, genotypic and environmental parameters. *C. R. Biologies*., 333: 248-253.

Osman., E.B.A. and M. M. M. Awed (2010). Response of sunflower (*Helianthus annuus* L.) to phosphorus and nitrogen fertilization under different plant spacing at new valley. *Ass. Univ. Bull. Environ. Res*., 13(1): 11-19.

Poonia, K. L. (2000). Effect of planting geometery, nitrogen and sulphur on growth and yield of sunflower (*Helianthus annuus* L.). *J. Eco-Physiology*, 3: 57-71.

Pouzet, A. and D. Delpancke (2000). Evolution comparee de la production et de la competitive te du tournesol dans differentes aires de production proc. 15th International conference, Toulouse, France Tome 1: AI-9.

Prasad, P. V. V., V. Satyanarayama., V. R. K. Murthy and K. J. Boote (2002). Maximizing yields in riceground cropping sequence through integrated nutrient management. *Field Crop Res*., 75: 9-21.

Reddy, S. R. (2004) . *Principles of crop production*. Kalyani Publishers. Ludhiana. India. Second Ed. pp-285.

Richards, L. A. (1954). *Diagnosis and Improvement of Saline and Alkali Soils, Determination of the properties of saline and alkali soils*. United States Department of Agriculture, Washington DC 26, 72.

Sadiq, S. A., M. Shahid, A. Jan and S. N. U. Din (2000). Effect of various levels of NPK on growth, yield and yield components of sunflower. *Pak J. Bio. Sci*., 3(2): 338-339.

Sadras, V. O. (2006). The NP stiochiometry of cereal, grain legume and oilseed crops. *Field Crop Res*., 95: 13-29.

Saleem, M. F. and M. A. Malik (2004). Agro-economic assessment of different phosphorous levels for diverse sunflower hybrids (*Helianthus annuus* L.). *J. Agric. Res*., 42 (3-4): 261-270.

Siddiqui, M. H., C. O. Fateh, M. K Abbasi and A. W. Gandahi (2009). Effect of NPK, micronutrients and N-placement on the growth and yield of sunflower. *Sarhad J. Agri*., 25 (1): 45-52.

Soleymani, A., M. H. Shahrajabian and L. Naranjani (2013). Effect of planting dates and different levels of nitrogen on seed yield and yield components of nuts sunflower (*Helianthus annuus* L.). *African J Agric. Res*., 8(46), pp. 5802-5805.

Soltanpour, P. N. (1985). Use of AB-DTPA to evaluate elements availability and toxicity. *Commun. Soil Sci. and Plant Anal*., 16: 323-338.

Steel, R. G. D., J. H. Torrie and D. A. Dickey (1997). *Principles and Procedures of Statistics. A Biometrical approach*, 3rd Edn., McGraw Hill Book Co., NewYork, pp: 172-177.

Syed, T. H. M., M. R. Ganai, A.Tahir and A. Shahid (2003). Effects of N x S interaction on the nutrient uptake, yield and quality of sunflower (*Helianthus annuus* L.) under temperate conditions of Kashmir. *Nat. J. Plant Improv.*, 5: 47-49.

Tandon, H. L. S. (2004). Fertilizers in India. *Agri. Farming Outlook*, 4 (2): 17-22.

Thavaprakash, N., G. Senthilkumar, S. D. Sivakumar, and M. Raju (2003). Photosynthetic attributes and seed yield of sunflower (*Helianthus annuus* L.) as influenced by different levels and ratios of nitrogen and phosphor us fertilizers. *Acta Agro. Hungarica*., 51(2):149-155.

Tisdale, S. L., W. L. Nelson, J. D. Beaton and J. L. Havlin (2003). *Soil Fertility and Fertilizers* (5th edition). Prentice-Hall of India. Prt Ltd. New Delhi.

(*Accepted for publication November 2016*)