# NUTRITIONAL YIELD AND ECONOMIC RESPONSES OF SUNFLOWER (*Helianthus annuus* L.) TO INTEGRATED LEVELS OF NITROGEN, SULPHUR AND FARMYARD MANURE

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## *ABSTRACT*

*The field experiments were conducted at Agronomy Farm of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during 2009 and 2010, to study the Nutritional yield and economics response of sunflower (Helianthus annuus L.) grown under varying levels of nitrogen, sulphur and farmyard manure. The experiment was laid out in a randomized block design with three nitrogen levels (40, 80 and 120 kg/ha), two sulphur levels (30 and 60 kg/ha) and three FYM levels (0, 10 and 20 t/ha) having 18 treatment combinations with three replications. The plots were given uniform recommended dose of phosphorus and potassium through diammonium phosphate and muriate of potash at the rate of 60 and 40 kg* $P_2O_5$ *and* $K_2O$ */ha, respectively. The soil of the experimental field was silty clay loam in texture, low in available nitrogen and sulphur, high in organic carbon, medium in available phosphorus and potassium with neutral pH. The plant height, leaf area index and dry matter production recorded significant and consistent increase with increase in nitrogen rates from 40 to 120 kg/ha. Nitrogen rates of 80 and 120 kg/ha at par with one another, significantly increased the total number of achenes/capitulum, number of filled achenes/capitulum and 1000-seed weight over 40 kg N/ha. The luxurious seed yield (2.5 tonnes/ha) was recorded with 120 kg N/ha which remained at par with 80 kg N/ha (2.4 t/ha) and net returns (Rs. 53793), B:C (2.1) ratio was higher with 120 kg N/ha. Application of 60 kg S/ha recorded maximum seed yield (2.42 tonnes/ha) and net returns (Rs. 49115). Same dose of treatment also recorded higher oil content and oil yield. Application of FYM @ 10 and 20 t/ha improved seed yield up to the tune of 9 and 15% over no application, respectively. With net returns of Rs. 49093 FYM @ 10 t/ha proved more profitable. Available nitrogen recorded was highest with treatment combination 120 kg N+60 kg S+20 t FYM/ha and lowest with 40 kg N+30 kg S+0 t FYM/ha. Similar trend was observed for available sulphur.*

**Keywords:** *achene yield, economics, FYM, oil content, nitrogen, sulphur, sunflower*

## INTRODUCTION

Oil seeds play an important role in Indian agriculture as food and an industrial commodity. India is the largest producer of oilseeds in the world in terms of output and in terms of area. Among the oilseed crops, sunflower (*Helianthus annuus* L.), is an all-season crop. In India, it is cultivated over an area of about 2.4 million hectares with a production of 1.44 million tonnes (Anonymous, 2008). To the Kashmir valley, it has been recently introduced, where hardly any oilseed crop is cultivated in *kharif* (June-September) season. It is a crop with short duration and photo-insensitivity, suits well to rainy season (Thimmegowda *et al.,* 2007). Nitrogen is the most important limiting nutrient

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required by the plant. It helps in the early growth, better assimilation of carbohydrates and synthesis of proteins. Nitrogen also affects the seed quality by increasing proteins and decreasing oil concentration (Gudade *et al.,* 2009). Sulphur is also increasingly being recognized as the fourth major plant nutrient next to nitrogen, phosphorus and potassium (Tendon and Messick, 2002). It helps in the synthesis of cystein, methionine, chlorophyll, vitamins (B, biotin and thiamine), metabolism of carbohydrates, increasing oil and protein contents as well as is associated with growth and metabolism, especially affecting the protolytic enzymes (Najar *et al.,* 2011). For higher productivity and sustainability, integrated use of organic and inorganic sources of nutrients is considered to be very important. It is a well established fact that regular integrated use of fertilizer, organic manures and residues in rotation is essential for sustaining moderate to high crop yields, at the same time improving soil organic matter and fertility (Sharma *et al.,* 2008). The chemical fertilizer is supplied along with organic materials, the yield decrement, if any in the initial years can overcome by enhanced mineralization of nutrients from fresh organic materials with wide C:N ratios by supplementing with slightly higher fertilizer doses. The strength of the conjunctive use system also lies in its ability to meet the short term as well as the long term nutrient requirements of crop through the fast releasing fertilizer nutrient pool and the slow releasing organic nutrient pool, respectively. Hence, there is need to generate quantifiable information on comparison of response and performance of varying rates of sole organic and inorganic nutrients and their conjunctive use in terms of yield and effect on soil fertility and overall soil quality. Apart from providing both macro and micronutrients, FYM increases the availability of added inorganic nutrients resulting in the positive effect on the photosynthetic surface, thereby improved the yield (Byrareddy *et al.,* 2008) In view of above the present investigation was carried out to study the effect of nitrogen, sulphur and farmyard manure applications on growth and yield of sunflower under temperate conditions.

## MATERIALS AND METHODS

The field experiment was conducted for 2-consecutive rainy (*kharif*) seasons of 2009 and 2010 at the Research farm, Division of Agronomy, Sher–e–Kashmir University of Agricultural Sciences and Technology of Kashmir situated between 34°.05¢ N latitude and 74°.89¢ E longitude at an altitude of 1587 meters above mean sea level. The soil was a silty clay loam having 1.4 % coarse sand 18.2% fine sand 42.4% silt and 38% clay and a *p*H of 6.5, 0.87% organic carbon and 271.5, 14.3, 160 and 15.7 kg/ha available N, P, K and S , respectively. The precipitation was 177.8 and 249.9 mm during the cropping seasons of 2009 and 2010, respectively. The experiment was laid out in a factorial randomized block design, having 18 treatment combinations with three replications. The treatments comprised of three nitrogen levels *viz*. 40, 80 and 120 kg N/ha, two sulphur levels *viz*. 30 and 60 kg S/ha and three FYM treatments *viz*. 0, 10 and 20 tonnes/ha. The sequence of crops grown in experimental field during past three years is summarized in Table 01.Well decomposed FYM (having C:N ratio of 10-12:1) as per treatment was applied to the respective plots and incorporated. Phosphorus at 60 kg $P_2O_5$/ha and potassium at 40 kg $K_2O$/ha were uniformly applied to each plot as a basal dose during both years of experimentation. Remaining half dose of nitrogen was applied in two equal splits one each at 30-35 DAS and flowering stage. Nitrogen, phosphorus, potassium and sulphur were applied in form of urea, di-ammonium phosphate, muriate of potash and calcium sulphate dihydrated ($CaSO_4$ $2H_2O$), respectively. After opening of furrows, the overnight soaked seed of sunflower variety of "*Morden*" was sown on 24 and 25 June in 2009 and 2010 respectively. The crop was thinned at 15 DAS to retain one seedling per hill at 45 cm spacing. Light irrigation was given to the crop towards ending June during both the years. Five random plants were selected from each treatment, excluding the border row, for taking observation on plant height. The leaf area index was recorded using canopy analyzer (Accu PAR Model LP-80). For dry matter, representative plant samples in penultimate rows of each plot were dried in shade followed by oven drying at 60-65$^0$C to a constant weight. Observations on yield parameters were recorded from five randomly selected plants of each treatment. Crop was harvested manually on 24 and 26 September in 2009 and 2010, respectively. Yield was recorded from net plots, leaving border and penultimate rows. The oil content in seed was determined with Nuclear Magnetic Resonance Spectroscope (Ne Port Analyser Model MK III A) employing non-destructive method of oil estimation in seed. Available nitrogen was determined by “Alkaline Potassium Permanganate Method” (Subbiah and Asija, 1956) and available sulphur by “Turbidimetric method” (Chesnin and Yien, 1960) and recorded in kg/ha. Economics was worked out using prevailing market prices of inputs and produce. The data obtained in respect of observation were statistically analyzed by the described by Cochran and Cox (1963). The significance of “F” and “t” was tested at 5% level of significance. The critical difference value was determined when “F’ test was significant.

## RESULTS AND DISCUSSION

### *Effect on crop growth*

The data on growth parameters and yield attributes as influenced by treatments are presented in Table 02 and it revealed a significant increase in growth parameters of sunflower, *viz*. plant height, leaf area index and dry matter accumulation along with the increase in nitrogen level from 40 to 120 kg/ha. Growth with respect to these characters was higher with application of 120 kg N/ha, followed by 80 kg N/ha. Since nitrogen is a major constituent of chlorophyll and proteins and its adequate supply through fertilizer encouraged the photosynthesis, the results indicated a better crop growth. Increase in growth attributes in sunflower due to nitrogen application have been reported by Shah and Khanday (2005) and Sarkar and Mallick (2009). Application of sulphur at 60 kg/ha recorded consistent improvement in plant height, leaf area index and dry matter production over 30 kg S/ha. This could be observed to the pivotal role of sulphur in regulating the metabolic and enzymatic processes including photosynthesis and respiration as reported by Sreemannarayana and Raju (1994) and Intodia and Tomar (1997). Farmyard manure (FYM) significantly improved the growth parameters of sunflower. Incorporation of FYM at 20 t/ha improved the growth parameters over no application. This might be due to improvement in soil physical, chemical and biological properties, provision of plant growth influencing material such as auxin, amino acids and vitamins produced by their decay which promote the plant growth, increased nutrition status due to addition of organic manure and adds the micro-nutrients. These results are in conformity with the findings of Melo and De-Oliveira (1999), Imayavarambani *et al.,* (2002), and Ahmad and Jabeen (2009).

**Table 01: Cropping history of the experimental field**

| Year | *Kharif* | *Rabi* |
|---|---|---|
| 2007-08 | Maize | Lentil based intercropping |
| 2008-09 | Maize | Lentil based intercropping |
| 2009 *(Kharif)* | Sunflower (Experimental) | - |
| 2010 *(Kharif)* | Sunflower (Experimental) | - |

**Table 02: Growth parameters of sunflower as influenced by nitrogen, sulphur and FYM levels (pooled over two years)**

| Treatment | Plant height (cm) | Leaf Area Index | Dry matter (t/ha) |
|---|---|---|---|
| Nitrogen levels (kg/ha) | | | |
| 40 | 106.4 | 0.50 | 6.15 |
| 80 | 112.0 | 0.82 | 6.89 |
| 120 | 115.9 | 0.96 | 7.20 |
| SE (m) ± | 1.14 | 0.04 | 0.103 |
| CD (p=0.05) | 3.31 | 0.11 | 0.298 |
| Sulphur levels (kg/ha) | | | |
| 30 | 110.24 | 0.68 | 6.59 |
| 60 | 112.70 | 0.84 | 7.40 |
| SE (m) ± | 0.93 | 0.03 | 0.084 |
| CD (p=0.05) | 2.7 | 0.09 | 0.243 |
| FYM levels (t/ha) | | | |
| 0 | 108.57 | 0.62 | 6.31 |
| 10 | 112.50 | 0.82 | 6.91 |
| 20 | 113.38 | 0.84 | 7.01 |
| SE (m) ± | 1.14 | 0.04 | 0.103 |
| CD (p=0.05) | 3.31 | 0.11 | 0.298 |

### *Effect on Yield Attributes and Seed Yield*

Yield attributes, notably capitulum diameter, achenes/capitulum and 1000-seed weight increased progressively with increase in nitrogen level up to of 120 kg/ha. This may be ascribed to the overall improvement in crop vigour and production of sufficient photosynthates owing to higher availability of nitrogen (Awasthi *et al.,* 2011). Nitrogen @120 kg/ha, at par with 80 kg N/ha, recorded maximum seed yield over both the years of experimentation (Table 03). Enhancement in yield on pooled basis was 26 and 20% with 120 and 80 kg N/ha over 40 kg N/ha, respectively. The possible reason might be positive response of agronomic characteristics associated with yield to nitrogen. Similar findings were reported by Syed *et al.,* (2006). Sulphur application significantly influences the yield contributing characters. Application of 60 kg S/ha significantly increased the head diameter, filled achenes/capitulum and 1000-seed weight over 30 kg S/ha. Synthesis of proteins at higher sulphur level may have resulted in proper partitioning of photosynthates from source to sink resulting in the improvement in yield contributing characters. Seed yield increased significantly by 7.5 % with 60 kg S/ha over 30 kg S/ha. These results corroborate the findings of Ravi *et al.,* (2008). Significant improvement in yield components and seed yield was observed with application of farmyard manure, which sustained better crop growth, produced better yield attributes and ultimately higher seed yield during both the years. Increase in grain yield with 10 and 20 tonnes/ha of farmyard manure was to the tune of 9 and 15% over no application, respectively. FYM seems to act directly in increasing crop yields either by acceleration of respiratory process by increasing cell permeability by hormone growth action or by combination of all the processes viz., release of nutrients and improving soil physical, chemical and biological properties. The beneficial effect of FYM on sunflower is well documented by Awad and Geeresh (1992), Sathiyavelu *et al.*, (1994), Singh *et al.,* (1996) and Manjunatha *et al.,* (2009).

**Table 03: Yield attributes and yields of sunflower as influenced by nitrogen, sulphur and FYM levels**

| Treatment | Plant height (cm) | Leaf Area Index | Dry matter (t/ha) | Seed yield (t/ha) | Stalk yield (t/ha) |
|---|---|---|---|---|---|
| Nitrogen levels (kg/ha) | | | | | |
| 40 | 106.4 | 0.50 | 6.15 | 2.03 | 4.21 |
| 80 | 112.0 | 0.82 | 6.89 | 2.43 | 4.78 |
| 120 | 115.9 | 0.96 | 7.20 | 2.55 | 5.20 |
| SE (m) ± | 1.14 | 0.04 | 0.103 | 0.06 | 0.07 |
| CD (p=0.05) | 3.31 | 0.11 | 0.298 | 0.18 | 0.21 |
| Sulphur levels (kg/ha) | | | | | |
| 30 | 110.24 | 0.68 | 6.59 | 2.23 | 4.63 |
| 60 | 112.70 | 0.84 | 7.40 | 2.45 | 4.84 |
| SE (m) ± | 0.93 | 0.03 | 0.084 | 0.05 | 0.06 |
| CD (p=0.05) | 2.7 | 0.09 | 0.243 | 0.14 | 0.17 |
| FYM levels (t/ha) | | | | | |
| 0 | 108.57 | 0.62 | 6.31 | 2.16 | 4.42 |
| 10 | 112.50 | 0.82 | 6.91 | 2.35 | 4.63 |
| 20 | 113.38 | 0.84 | 7.01 | 2.51 | 5.15 |
| SE (m) ± | 1.14 | 0.04 | 0.103 | 0.63 | 0.07 |
| CD (p=0.05) | 3.31 | 0.11 | 0.298 | 0.18 | 0.21 |

### *Effect on Oil Content and Oil Yield*

Oil content recorded significant decrease with increase in the levels of nitrogen up to 120 kg/ha (Table 04). This might be attributed to increased availability of nitrogen at higher rates of nitrogen application, which resulted in greater accumulation of protein in plants and reduces availability of carbohydrates for polymerization into fatty acids, which in turn lower content of oil in the seed. The oil yield increased significantly and consistently with increase in nitrogen levels up to 120 kg /ha. These results confirm the findings of Ozer *et al.,* (2004) and Aglave *et al.,* (2009). Application of higher level of sulphur significantly increased the oil content and oil yield. Increase in oil content with 60 kg S/ha was 3 and 2.4% over 30 kg S/ha during 2009 and 2010, respectively. Oil yield increased by 13.6 and 10% with 60 kg S/ha over 30 kg S/ha during 2009 and 2010, respectively. Oil yield is a function of oil content and seed yield and both the parameters increased with higher sulphur level, thus resulting in a significant increase in oil yield. An increase in oil content and oil yield in sunflower due to sulphur application was also earlier reported by Rani *et al.,* (2009). There was significant increase in oil content and oil yield with increase in FYM application. Application of FYM at 20 tonnes/ha remained at par with FYM at 10 tonnes/ha. Increase in oil yield was 10. 4 and 18.6% during 2009 and 14.3 and 19% during 2010 with the application of FYM at 10 and 20 tonnes/ha over no application, respectively. The findings corroborate with those of Helmy and Ramadan (2009).

**Table 04: Oil content and oil yield of sunflower as influenced by nitrogen, sulphur and FYM levels**

| Treatment | Oil content (%) | | Oil yield (t/ha) | |
|---|---|---|---|---|
| | 2009 | 2010 | 2009 | 2010 |
| Nitrogen levels (kg/ha) | | | | |
| 40 | 40.83 | 40.96 | 0.83 | 0.82 |
| 80 | 40.03 | 40.00 | 0.97 | 0.98 |
| 120 | 39.86 | 39.48 | 1.02 | 1.01 |
| SE (m) ± | 0.239 | 0.360 | 0.010 | 0.006 |
| CD (p=0.05) | 0.690 | 1.040 | 0.031 | 0.018 |
| Sulphur levels (kg/ha) | | | | |
| 30 | 39.64 | 39.70 | 0.88 | 0.89 |
| 60 | 40.84 | 40.66 | 1.00 | 0.98 |
| SE (m) ± | 0.195 | 0.294 | 0.009 | 0.005 |
| CD (p=0.05) | 0.560 | 0.850 | 0.025 | 0.015 |
| FYM levels (t/ha) | | | | |
| 0 | 39.70 | 39.20 | 0.86 | 0.84 |
| 10 | 40.45 | 40.64 | 0.95 | 0.96 |
| 20 | 40.57 | 40.70 | 1.02 | 1.00 |
| SE (m) ± | 0.239 | 0.360 | 0.011 | 0.006 |
| CD (p=0.05) | NS | NS | 0.031 | 0.018 |

***Effect on Available Nutrients in Soil***

The available nitrogen in the soil after crop harvest during 2009 and 2010 was not much affected by various treatments (Table 05). The lowest available nitrogen (269.00 kg/ha in 2009 and 270.17 kg/ha in 2010) was recorded with treatment combination 40 kg N + 30 kg S/ha along with 0 t FYM/ha and the highest (273.6 kg/ha in 2009 and 273.9 kg/ha in 2010) was found with combination of 120 kg N + 60 kg S/ha along with 20 t FYM/ha as against initial available nitrogen (271.4 kg/ha in 2009 and 271.8 kg/ha in 2010). This might be attributed to various losses of nitrogen in the soil i.e. denitrification, volatilization etc. Higher available nitrogen in the soil recorded with treatment combination containing 20 t FYM/ha could be attributed to higher rate of mineralization of organic nitrogen in the soil. A similar trend have also been reported by Thimmegowda *et al.,* (2007). Available sulphur in soil showed a marginal increase with different combinations. The lowest available sulphur (15.85 kg/ha in 2009 and 15.92 kg/ha in 2010) was recorded with treatment combination 40 kg N + 30 kg S/ha along with 0 t FYM/ha $N_1S_1F_1$ and the highest available sulphur (18.72 kg/ha in 2009 and 18.82 kg/ha in 2010) was obtained with treatment combination 120 kg N + 60 kg S/ha along with 20 t FYM/ha against initial availability of 15.68 and 15.80 kg/ha in 2009 and 2010, respectively.

**Table 05: Available nitrogen and sulphur (kg/ha) in soil after crop harvest as affected by different levels of nitrogen, sulphur and FYM**

| Treatment Combinations | Added to crop (kg/ha) | | | Uptake by crop (kg/ha) | | Available in soil after harvest (kg/ha) | |
|---|---|---|---|---|---|---|---|
| | Organic Nitrogen | Inorganic Nitrogen | Inorganic Sulphur | Nitrogen | Sulphur | Nitrogen | Sulphur |
| $N_{40}S_{30}F_0$ | - | 40.00 | 30.00 | 54.84 | 11.38 | 269.75 | 15.92 |
| $N_{40}S_{30}F_{10}$ | 50 | 40.00 | 30.00 | 67.34 | 12.47 | 272.60 | 16.32 |
| $N_{40}S_{30}F_{20}$ | 100 | 40.00 | 30.00 | 72.66 | 13.14 | 273.70 | 16.75 |
| $N_{40}S_{60}F_0$ | - | 40.00 | 60.00 | 66.86 | 13.19 | 270.17 | 18.32 |
| $N_{40}S_{60}F_{10}$ | 50 | 40.00 | 60.00 | 79.36 | 14.27 | 272.10 | 18.45 |
| $N_{40}S_{60}F_{20}$ | 100 | 40.00 | 60.00 | 84.68 | 14.92 | 273.10 | 18.48 |
| $N_{80}S_{30}F_0$ | - | 80.00 | 30.00 | 72.51 | 12.53 | 269.80 | 16.00 |
| $N_{80}S_{30}F_{10}$ | 50 | 80.00 | 30.00 | 85.01 | 13.61 | 271.80 | 16.08 |
| $N_{80}S_{30}F_{20}$ | 100 | 80.00 | 30.00 | 90.33 | 14.29 | 272.90 | 16.64 |
| $N_{80}S_{60}F_0$ | - | 80.00 | 60.00 | 84.53 | 14.35 | 270.20 | 18.55 |
| $N_{80}S_{60}F_{10}$ | 50 | 80.00 | 60.00 | 97.03 | 15.42 | 271.90 | 18.64 |
| $N_{80}S_{60}F_{20}$ | 100 | 80.00 | 60.00 | 102.3 | 16.10 | 273.10 | 18.67 |
| $N_{120}S_{30}F_0$ | - | 120.00 | 30.00 | 82.76 | 14.75 | 270.90 | 16.01 |
| $N_{120}S_{30}F_{10}$ | 50 | 120.00 | 30.00 | 95.26 | 13.61 | 273.00 | 16.22 |
| $N_{120}S_{30}F_{20}$ | 100 | 120.00 | 30.00 | 100.5 | 14.34 | 273.80 | 16.50 |
| $N_{120}S_{60}F_0$ | - | 120.00 | 60.00 | 94.78 | 14.86 | 271.10 | 18.63 |
| $N_{120}S_{60}F_{10}$ | 50 | 120.00 | 60.00 | 107.2 | 15.95 | 273.20 | 18.69 |
| $N_{120}S_{60}F_{20}$ | 100 | 120.00 | 60.00 | 112.6 | 16.62 | 273.90 | 18.82 |

* FYM contains 0.5%

**Table 06: Economics of sunflower as influenced by nitrogen, sulphur and FYM levels**

| Treatment | Cost of cultivation (Rs/ha) | Net returns (Rs/ha) | B:C ratio |
|---|---|---|---|
| Nitrogen levels (kg/ha) | | | |
| 40 | 24310 | 38365 | 1.6 |
| 80 | 24794 | 50498 | 2.0 |
| 120 | 25278 | 53797 | 2.1 |
| SE (m) ± | - | - | - |
| CD (p=0.05) | - | - | - |
| Sulphur levels (kg/ha) | | | |
| 30 | 24938 | 44867 | 1.8 |
| 60 | 25875 | 49115 | 1.9 |
| SE (m) ± | - | - | - |
| CD (p=0.05) | - | - | - |
| FYM levels (t/ha) | | | |
| 0 | 19017 | 47983 | 2.5 |
| 10 | 24017 | 49093 | 2.0 |
| 20 | 29017 | 48208 | 1.7 |
| SE (m) ± | - | - | - |
| CD (p=0.05) | - | - | - |

***Effect on Economics***

The efficiency of a treatment is finally decided in terms of the economics (benefit cost ratio) of that treatment. Net returns (Rs. 5379/ha) and B: C ratio (2.1) were higher with nitrogen application at 120 kg/ha (Table 06). Application of 80 kg N/ha with net profit of Rs. 50498 and B : C ratio 2.0 remained second in order. sulphur at 60 kg/ha recorded higher net returns (Rs. 49115/ha) and B:C ratio (1.9) than 30 kg S/ha. Farmyard manure application also improved monetary returns with net returns of Rs. 49093, FYM at10 tonnes/ha proved more profitable over rest of the treatments. B:C ratio was higher (2.5) when FYM was not applied.

## CONCLUSION

Based on the foregoing results, it can be concluded that highest values of sunflower yield, monetary return, yield quality and its components as well as nutrient uptake and available nutrients in the soil were obtained with the plants supplied with 120 kg N + 60 kg S $ha^{-1}$ with 20 t FYM $ha^{-1}$ However, for maintaining soil health 80 kg N + 60 kg S + 10 t FYM $ha^{-1}$ nutrient dose could be recommended for maximum profit under temperate Kashmir conditions.

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