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# IMPACT OF VARYING PLANTING PATTERNS AND FERTILIZER APPLICATION STRATEGIES ON AUTUMN PLANTED SUNFLOWER HYBRID

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**ABSTRACT.** Achene yield, oil contents and protein contents are vital yield attributes of sunflower crop. To acquaint the impact of NP rates and planting patterns on the production potential of autumn sunflower hybrid Hysun-33 and fertilizer use efficiency a field experiment was executed in 2005. Treatments comprised of four NP combinations viz. 0-0, 50-35, 100-70 and 150-105 NP kg $ha^{-1}$ and two planting patterns viz. bed sowing with 75 cm wide beds separated by 20 cm furrows and bed sowing with 60 cm wide beds separated by 25 cm furrows. Treatment 150-105 NP kg $ha^{-1}$ with 75 cm wide beds separated by 20 cm furrows was found to be supercilious as it exhibited significant lofty achene yield (3360.00 kg $ha^{-1}$), number of achene $head^{-1}$ (1267.02), 1000-achene weight (68.65 g), biological yield (11166.6 kg $ha^{-1}$) and harvest index (30.09%). Contrastingly, treatment 0-0 N-P kg $ha^{-1}$ with 60 cm wide bed separated by 25 cm plant spacing bestowed the minimum grain yield. Frail increase in oil contents with gradual increase in fertilizer levels but it did not procure at a level of significance. Superior protein contents (27.71%) were revealed in treatment 150-105 N-P kg $ha^{-1}$ with 75 cm wide bed separated by 20 cm plant spacing.

**Key words**: Achene yield; Biological yield; Oil contents; Plant spacing; Protein contents.

## INTRODUCTION

Sunflower is the world's fourth biggest oilseed crop (Petcu *et al.,* 2010). It is an important non-conventional oilseed crops. Because of high quality edible oil, it enjoys an important position among the new

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oilseed crops. Its seeds contain 25-48% oil (Hatam and Abbasi, 1994). In Pakistan, rape seeds and mustards, ground nut, castor bean, sesame and linseed are conventional oilseed crops and are being grown in the country for long period. While sunflower, soybean and safflower are non-conventional oilseed crops and been introduce recently in the country. But the major oilseed crops include sunflower, canola, rapeseed and mustard and cottonseed (Nazir, 1994). The local oilseed production in 2010-'11 is 696 thousand tons. Sunflower crop contributes an area 449 thousand hectors, with average production of 643 thousand tons seed yield and 244 thousand tons oil yield (Anonymous, 2010). This yield level is very low as compared to potential yield of many sunflower hybrids. Among various factors responsible for low yield, management of fertilizers and planting pattern may be of much importance. Plant population is the basic component of package production technology, but more important than this, is the proper adjustment of plants in field. Ali *et al.* (2007) obtained higher achene yield and oil contents of sunflower by sowing it 60 cm apart rows keeping a plant to plant distance of 20 cm. Similarly, Dar *et al.* (2009) recorded maximum leaf area index (LAI), net assimilation rate (NAR), crop growth rate (CGR) and highest achene yield in 60 cm spaced single row ridge sowing of sunflower. Iqbal *et al.* (2007) also revealed maximum achene yield (2821.89 kg $ha^{-1}$) with 60 cm x 22.5 cm planting pattern.

No doubt, the application of nutrients, particularly nitrogen (N) and phosphorus (P), either in the form of bio-fertilizer (Ahmed *et al.,* 2010) or artificial fertilizers, play a vital role in boosting up production in sunflower. Killi (2004) obtained high seed yield (4.3 t $ha^{-1}$) and oil yield (1.7 t $ha^{-1}$) by different levels of nitrogen application. But maximum inherent potential of a variety can only be achieved when nutrients are applied in balanced form with recommended dose of fertilizers (RDF) (Murali *et al.,* 2009). However, the effect of N application on the oil content of sunflower seed is somewhat controversial. Kamel *et al.* (1980) reported that nitrogen application did not affect the oil content of sunflower seed either way. On the other hand, Blamey and Chapman (1981) observed that increased doses of N application decreased the oil content of sunflower seed. Maximum plant height (87.54 cm), seed yield ha-1 (1302.75 kg) and leaf area $plant^{-1}$ (9909.5 $cm^2$) was achieved in plots with highest dose of nitrogen (225 kg $ha^{-1}$) (Qahar *et al.,* 2010). Phosphate compounds act as energy currency within the plant. Plants suffering from P deficiency are retorted in growth and the shoot root dry matter ratio is usually low. Thus not only low yield but also poor quality fruit and seed are obtained from P deficiency in crops (Mengel and Kirkby, 1987). Therefore, this study was conducted to determine the

best performance of autumn sown sunflower hybrid Hysun-33 under varying plant spacing and different levels of nitrogen and phosphorus on its yield, oil and protein contents.

## MATERIALS AND METHODS

Field experiment was performed at the Agronomic Research Farm, University of Agriculture Faisalabad, Pakistan, to know the effect of NP rates and planting patterns on the production potential of autumn sunflower hybrid Hysun-33 and fertilizer use efficiency. Before sowing, soil samples were drawn to a depth of 30 cm and were analyzed for available NP already present in the soil. *Table 1* shows the physical and chemical analysis of soil contained sandy clay loam soil texture.

The meteorological data for the experimental was collected from the meteorological observatory of the Department of Crop Physiology, University of Agriculture Faisalabad, Pakistan, and is given in *Fig. 1*.

**Table 1 - Physical and chemical analysis of soil**

| Sr. No. | Determination | |
|---|---|---|
| 1. | pH | 7.9 |
| 2. | Organic matter (%) | 0.74 |
| 3. | Available P (ppm) | 9.38 |
| 4. | Available K (ppm) | 147 |
| 5. | Total N (%) | 0.045 |
| 6. | Saturation (%) | 35.8 |
| 7. | Texture | sandy clay loam |

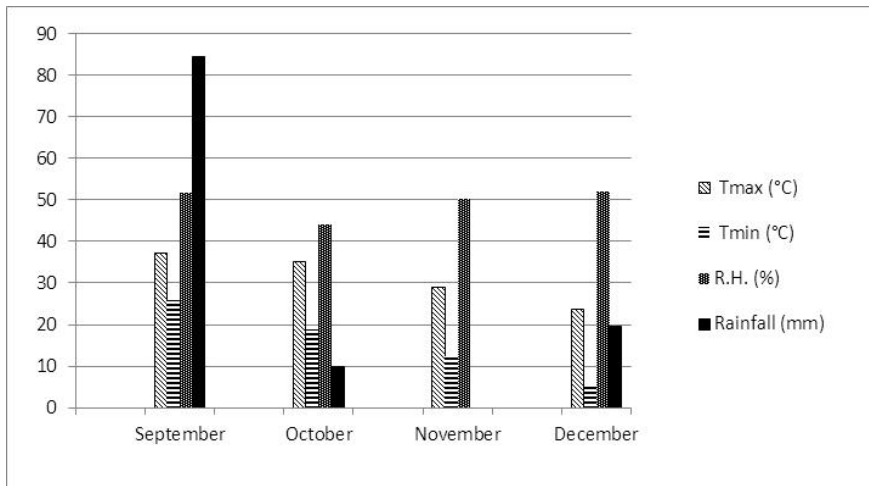


**Figure 1 - Meteorological data during the growing season of sunflower crop. The sunflower hybrid Hysun-33 was used as test crop.**

**Table 2 - Treatments used in the field experiment**

| Treatments | |
|---|---|
| **Planting patterns** | **NP fertilizers combinations** |
| Bed sowing with 75 cm wide beds separated by 20 cm furrows. | 0-0 NP kg $ha^{-1}$ |
| | 50-35 NP kg $ha^{-1}$ |
| | 100-70 NP kg $ha^{-1}$ |
| | 150-105 NP kg $ha^{-1}$ |
| Bed sowing with 60 cm wide beds separated by 25 cm furrows. | 0-10 NP kg $ha^{-1}$ |
| | 50-35 NP kg $ha^{-1}$ |
| | 100-70 NP kg $ha^{-1}$ |
| | 150-105 NP kg $ha^{-1}$ |

The experiment was laid out in randomized complete block design with split plot arrangement and replicated three times. The net plot size was 3.0 m x 5.0 m. Planting patterns were placed in main plots and fertilizers treatments were placed in sub plots (*Table 2*). The sowing was done with the help of manual drill using seed rate of 6 kg $ha^{-1}$. Later on, plant-to-plant distance was maintained manually by thinning. Fertilizer was applied in such a way that half of nitrogen and whole of phosphorus was applied at sowing time and remaining amount of nitrogen with first irrigation after 20 days of sowing and irrigation, thereafter, were applied according to the need of crop. The crop was kept weed free by hoeing manually during the growth period. Crop was harvested manually on December 28 in 2005. Agronomic parameters related to economic and biological yield of crop like, number of achenes $head^{-1}$, 1000-achene weight (g), biological yield (t $ha^{-1}$), achene yield (t $ha^{-1}$) and harvest index (HI) were recorded at crop maturity using their standard procedures. HI (%) which is the ratio of grain yield to biological yield was calculated by using the following formula:

Harvest index (HI) = (Achene yield / biological yield) x 100

The qualitative characteristics were also recorded. The achene oil (%) was determined by using petroleum ether (ethyl ether) as solvent in Soxhlet apparatus by the instructions described in (AACC, 2000). Similarly achene protein content (%) was estimated by the nitrogen present in each sample was determined by using Kjeldahl's method as described in (AACC, 2000).

The collected data was tabulated and analyzed statistically using Fisher's analysis of variance technique and Least Significance Difference (LSD) Test at 5 percent probability level was used to compare the treatments means (Steel and Torrie, 1984). Regression analyses between grain yield and other parameters were done to assess relationship among them. 'MSTATC' computer software was used for data analysis and Microsoft Excel, computer package was employed for regression analyses (Anonymous, 1986).

## RESULTS AND DISCUSSION

### Number of achenes $head^{-1}$

Number of achenes $head^{-1}$ is an important yield component, which contributes materially towards final achene yield of sunflower. *Table 3*

revealed that effect of N and P on this parameter was highly significant.

There were statistically significant differences among various fertilizer treatments. Maximum number of achenes head$^{-1}$ (1267.02) was recorded in plots, which were given 150-105 NP kg ha$^{-1}$ in both spacing's. Number of achene head$^{-1}$ gradually increased with increasing N and P rates. Minimum number of achene head$^{-1}$ (715.75) was recorded in control plots which were given 0-0 NP kg ha$^{-1}$. Planting patterns and the interaction between the factors was found to have non-significant effect on number of achenes head$^{-1}$. It is evident from the regression analysis that number of achenes head$^{-1}$ had a significant positive relationship ($R^2$ = 0.962) with achene yield (*Fig. 2*).

Results given by Latifi and Navabpour (1999) supported achene yield affected by different plant spacing. It might be due to well pulverized soil which support and anchor the sunflower plants roots well and deep, nourished them with essential nutrients for its growth and development and resulted in more values of yield contributing factor, number of achenes head$^{-1}$. Number of achene head$^{-1}$ gradually increased with increasing N and P rates (Malik *et al.,* 1992).

**Table 3 - Number of achenes head$^{-1}$ and 1000-achene weight (g) of autumn sunflower as affected by varying planting patterns and fertilizer application rates.**

| Fertilizer treatments N-P (kg ha$^{-1}$) | Planting patterns | | |
|---|---|---|---|
| | P1 = Bed sowing (75 cm apart beds) | P2 = Bed sowing (60 cm apart beds) | Fertilizer means |
| **Number of achenes head$^{-1}$** | | | |
| F1= 0-0 | 730.08 | 701.43 | 715.75 d |
| F2=50-35 | 880.76 | 841.55 | 861.15 c |
| F3=100-70 | 1087.33 | 1093.34 | 1090.33 b |
| F4=150-105 | 1260.29 | 1273.76 | 1267.02 a |
| Planting pattern means | 989.61 | 977.52 | |
| **1000-achene weight (g)** | | | |
| F1= 0-0 | 61.51 | 62.11 | 61.81 c |
| F2=50-35 | 62.84 | 63.47 | 63.16 b |
| F3=100-70 | 64.20 | 64.33 | 64.26 b |
| F4=150-105 | 68.73 | 68.57 | 68.65 a |
| Planting pattern means | 64.32 | 64.62 | |

Means not sharing the same letters differ significantly from each other at 5% probability level, and without letters are non-significantly different from each other.

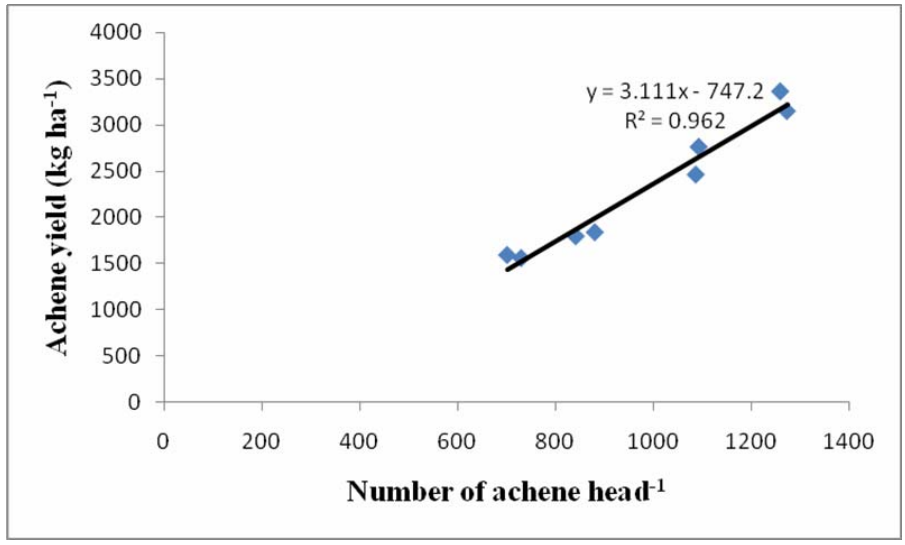


**Figure 2 - Relationship between number of achenes head$^{-1}$ and grain yield (kg ha$^{-1}$) in sunflower hybrid Hysun-33**

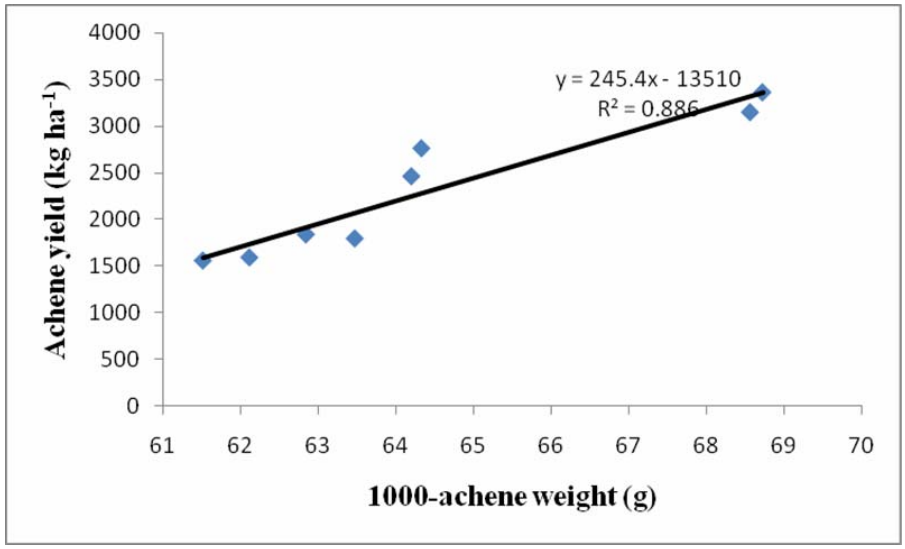


**Figure 3 - Relationship between 1000-achene weight (g) and grain yield (kg ha$^{-1}$) in sunflower hybrid Hysun-33**

**1000-achene weight (g)**

1000-achene weight contained a vital role in evaluating the yield potential of a crop as it expresses the enormity of grain development. Seed weight has a direct bearing on the formation of final seed yield of a crop. *Table 3* reflect that parameter under study was significantly affected by different N-P applications. Plots that were fertilized at the rate of 150-105 kg N-P per hectare produced the highest 1000-achene weight (68.65 g). Minimum 1000- achene weight was recorded in control plots (61.81 g). However, treatments 50-35 kg $ha^{-1}$ and 100-70 kg $ha^{-1}$ remained statistically at par with each other. Planting pattern did not have significant effect on 1000-achene weight. Similarly, the interaction between factors was also found to be non-significant. Regression analysis ($R^2$ = 0.886) revealed a significant positive association of 1000-achene weight with achene yield (kg $ha^{-1}$) (*Fig. 3*).

It was probably the result of physiological balance between vegetative and reproductive growth at this level in sunflower crop. Increase in 1000-achene weight is also due to the enhancement of strong relationship between the source efficiency (dry matter accumulation) and the sink capacity (achene weight) (Bindra and Kharwara 1992).

**Biological yield (kg $ha^{-1}$)**

Biological yield is overall expression of biological forces embodied in a production system, which are influenced by the treatments applied (Iqbal *et al.,* 2007). Biomass accumulation in sunflower is correlated with nutrient uptake through its life span. *Table 4* indicates that different fertilizer levels and planting patterns affected this parameter significantly. Similarly, the interaction between planting pattern and fertilizer found to be significant. Maximum biological yield (11166.6 kg $ha^{-1}$) was recorded by treatment 150-105 N-P kg $ha^{-1}$ at a plant distance of 75 cm x 20 cm, however; it was statistically at par with treatment 150-105 N-P kg $ha^{-1}$ and 60 cm x 25 cm plant spacing. The treatment 0-0 N-P kg $ha^{-1}$ and 60 cm x 25 cm plant spacing gave the minimum biological yield (6993.3 kg $ha^{-1}$) and it was statistically at par with treatment 0-0 kg N-P kg $ha^{-1}$ and 75 cm x 20 cm plant spacing. A significant positive effect ($R^2$ = 0.936) of biological yield on achene yield was shown by their regression analysis (*Fig. 4*).

These finding are in lined with Singh *et al.,* 1998 and Sarkar *et al.,* 1999; they documented similar results regarding nitrogen and phosphorus fertilizers.

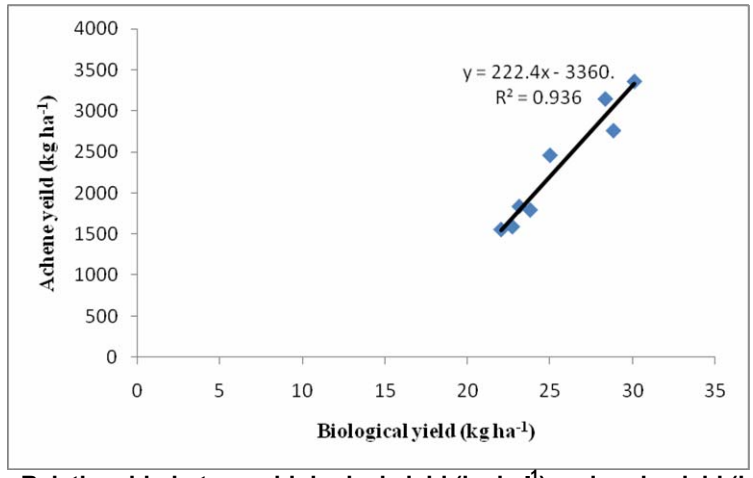


**Figure 4 - Relationship between biological yield (kg ha$^{-1}$) and grain yield (kg ha$^{-1}$) in sunflower hybrid Hysun-33**

**Table 4 - Biological yield (kg ha$^{-1}$), achene yield (kg ha$^{-1}$) and harvest index (%) of autumn sunflower as affected by varying planting patterns and fertilizer application rates.**

| Fertilizer treatments N-P (kg ha$^{-1}$) | Planting patterns | | |
|---|---|---|---|
| | P1 = Bed sowing (75 cm apart beds) | P2 = Bed sowing (60cm apart beds) | Fertilizer means |
| **Biological yield (kg ha$^{-1}$)** | | | |
| F1= 0-0 | 7056.6 f | 6993.3 f | 7025.0 d |
| F2=50-35 | 7933.3 d | 7533.3 e | 7733.3 c |
| F3=100-70 | 9836.6 b | 9573.3 c | 9705.0 b |
| F4=150-105 | 11166.6 a | 11103.3 a | 11140.0 a |
| Planting pattern means | 8998.3 a | 8800.8 b | |
| **Achene yield (kg ha$^{-1}$)** | | | |
| F1= 0-0 | 1556.66 f | 1590.00 f | 1573.33 c |
| F2=50-35 | 1836.66 e | 1793.33 e | 1815.00 c |
| F3=100-70 | 2460.00 d | 2760.00 c | 2610.00 b |
| F4=150-105 | 3360.00 a | 3146.66 b | 3253.33 a |
| Planting pattern means | 2303.33 | 2322.50 | |
| **Harvest index (%)** | | | |
| F1= 0-0 | 22.06 f | 22.74 ef | 22.32 c |
| F2=50-35 | 23.16 de | 23.81 d | 23.62 bc |
| F3=100-70 | 25.01 c | 28.83 b | 27.06 ab |
| F4=150-105 | 30.09 a | 28.34b | 29.25 a |
| Planting pattern means | 25.09 b | 26.03 a | |

Means not sharing the same letters differ significantly from each other at 5% probability level, and without letters are non-significantly different from each other.

**Achene yield (kg ha$^{-1}$)**

Final achene yield per hectare is a cumulative effect of various yield components that are head diameter, number of achenes per head and 1000-achenes weight, under the influence of a particular set of environmental conditions. *Table 4* showed that different fertilizer levels and the interactions between fertilizers and planting patterns produced significant effect on this parameter.

Maximum achene yield of 3360.00 kg ha$^{-1}$ was recorded in plots where treatment 150-105 N-P kg ha$^{-1}$ and 75 cm x 20 cm plant spacing was used. Effect of different planting patterns on achene yield was non-significant. Loubser and Human (1993), Tomar *et al.* (1997), Zubillaga *et al.* (2002) reported similar response of NP fertilizers to achene yield of sunflower. This may be due to the optimum level of the nutrient elements in soil and their availability to sunflower crop during its all physiological growth and development stages.

**Harvest index (%)**

Harvest index is a measure of measuring productive efficiency of a crop. *Table 4* reveals that various levels of fertilizer significantly affected the harvest index. Similarly, planting patterns and the interaction between fertilizers and planting patterns produced the significant effect on this parameter. Maximum value of harvest index (30.09%) was recorded with the treatment 150-105 N-P kg ha$^{-1}$ at a planting distance of 75 cm x 20 cm and minimum (22.06%) was obtained by the treatment 0-0 N-P kg ha$^{-1}$ and 75 cm x 20 cm plant spacing. However, it was statistically at par with 50-35 N-P kg ha$^{-1}$ with 75 cm x 20 cm plant spacing, 0-0 N-P kg ha$^{-1}$ with 60 cm x 25 cm plant spacing and 50-35 N-P kg ha$^{-1}$ with 60 cm x 25 cm plant spacing. Regression analysis revealed a significant positive relationship ($R^2$ = 0.936) of harvest index with achene yield (kg ha$^{-1}$) (*Fig. 5*).

**Achene oil contents (%)**

Achene oil content is generally considered that phosphorus is involved in synthesis of fatty acids. Quality of sunflower is determined by its oil contents. *Table 5* show slight increases in oil contents with gradual increase in fertilizer levels but it did not reach at a level of significance.

Moreover, planting patterns and interaction between fertilizers and planting patterns and interaction between fertilizer and planting patterns were also non-significant. A week relationship ($R^2$ = 0.658) between achene oil contents and achene yield was shown by their regression analysis (*Fig. 6*).

Results obtained are supported by Nandhagopal *et al.,* (1995) and with those of Nel *et al.,* (2000) who reported that oil contents were not affected significantly by increasing dose of NP and planting density too. The results obtained during the study are in contradiction with the findings of Barros *et al.* (2004) and Zarea *et al.* (2005) who reported an increase in oil yield with increase in planting density.

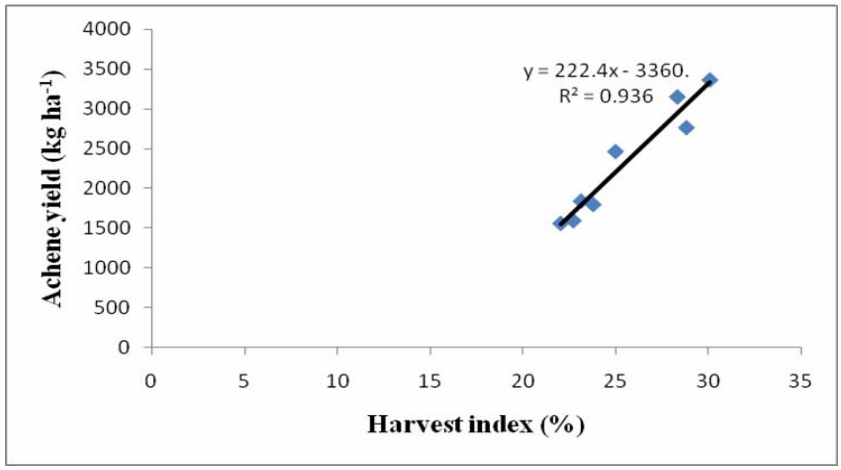


**Figure 5 - Relationship between harvest index (%) and grain yield (kg ha$^{-1}$) in sunflower hybrid Hysun-33**

**Table 5 - Achene oil contents (%) and achene protein contents (%) of autumn sunflower as affected by varying planting patterns and fertilizer application rates.**

| Fertilizer treatments N-P (kg ha$^{-1}$) | Planting patterns | | |
|---|---|---|---|
| | P1 = Bed sowing (75 cm apart beds) | P2 = Bed sowing (60 cm apart beds) | Means |
| **Achene oil contents (%)** | | | |
| F1= 0-0 | 39.65 | 39.56 | 39.61 |
| F2=50-35 | 40.80 | 40.41 | 40.60 |
| F3=100-70 | 41.15 | 40.11 | 40.63 |
| F4=150-105 | 41.87 | 41.69 | 41.78 |
| Means | 41.78 | 40.44 | |
| **Achene protein contents (%)** | | | |
| F1= 0-0 | 21.91 | 23.34 | 22.63 d |
| F2=50-35 | 22.34 | 24.54 | 23.44 c |
| F3=100-70 | 23.94 | 25.01 | 24.48 b |
| F4=150-105 | 27.51 | 27.91 | 27.71 a |
| Planting pattern means | 23.92 | 25.20 | |

Means not sharing the same letters differ significantly from each other at 5% probability level, and without letters are non-significantly different from each other.

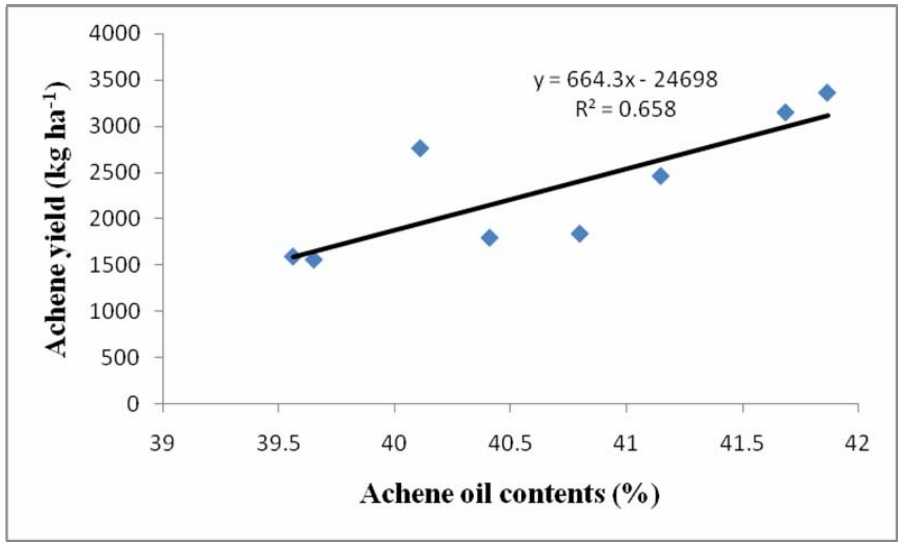


**Figure 6 - Relationship between achene oil contents (%) and grain yield (kg ha$^{-1}$) in sunflower hybrid Hysun-33**

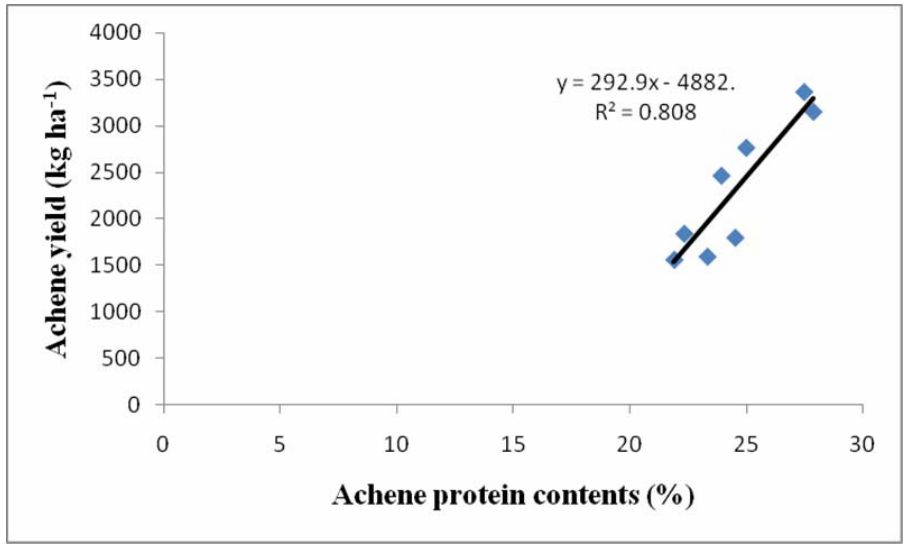


**Figure 7 - Relationship between achene protein contents (%) and grain yield (kg ha$^{-1}$) in sunflower hybrid Hysun-33**

**Achene protein contents (%)**

Quality of sunflower is also determined by its achene protein contents. *Table 5* explained that the parameter was greatly influenced by various NP levels. Highest value of achene protein contents (27.71%) was obtained in treatment 150-105 N-P kg $ha^{-1}$ and 75 cm x 20 cm plant spacing. Treatment 0-0 N-P kg $ha^{-1}$ with 60 cm x 25 cm plant spacing produced the minimum (22.63 %) protein contents. The planting patterns had non-significant effect on it. Similarly, the interaction between the factors was found to be non-significant. Regression analysis ($R^2$ = 0.808) revealed a significant positive association of achene protein contents (%) to achene yield (kg $ha^{-1}$) (*Fig.7*).

The increase in the protein yield may be due to the successive increase in nitrogen level in response to fertilizer treatment. Loubser and Human (1993) and Singh *et al*. (1998) also reported the similar result.

## CONCLUSION

Finally, it can be concluded that hybrid sunflower, Hysun-33, should be planted at a planting distance of 75 cm x 20 cm and be provided with 150-105 N-P kg $ha^{-1}$ to get maximum yield potential from it under irrigated condition of Pakistan.

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