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# Effect of NPK nutrition on leaf area index and chlorophyll content of fibre flax (*Linum usitatissimum* L.)

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## Abstract
From ancient period flax (*Linum usitatissimum* L.) is well known for its prime quality fibres called linen. Balanced nutrition of nitrogen, phosphorus and potassium is essential for optimum leaf area index of flax which ultimately leads to efficient photosynthesis and plant growth. However, literatures regarding the effect of nitrogen, phosphorus and potassium on leaf growth and chlorophyll content are limited. Concerning this aspect, a field experiment was conducted during two consecutive flax growing seasons of 2020-21 and 2021-22 at Pantnagar, Uttarakhand, India under Randomized Block Design with thirteen treatments of NPK dose combinations replicated three times. Increase in nitrogen dose from 60 to 120 kg/ha under same phosphorus and potassium levels, invariably enhanced leaf area index and total chlorophyll content. The highest LAI was recorded with application of 120:45:45 kg/ha N:$P_2O_5$:$K_2O$ which was closely followed by 90:45:45 kg/ha N:$P_2O_5$:$K_2O$. The total chlorophyll content was also the highest with application of 120:45:45 kg/ha N:$P_2O_5$:$K_2O$ having the value of 2.64 and 2.84 mg/g (on an average) at 60 and 90 DAS, respectively. LAI and chlorophyll content enhanced with increase in nitrogen rate however, effect of higher phosphorus and potassium on this aspect was found marginal.

**Keywords:** Flax, leaf area index, total chlorophyll content, nitrogen, phosphorus and potassium

## Introduction
Flax (*Linum usitatissimum* L.), under Linaceae family, is a fibre crop with great potential for its multiple uses and wider adaptability. Flax fibre is one of the few natural fibres successfully extracted in ancient times (Dey *et al*., 2022) [4]. The valuable fibre known as linen is obtained from the bark of its stem and traditionally used for bed sheets and garments. Flax fibre is of superior quality with greater breathability and cool nature combined with favourable water absorbing qualities have made linen to be mostly preferred by the consumers in warmer climates around the world (FAO, 2009) [5]. Although flax fibres are coarser than cotton fibres, they are more stronger as well as durable (Yan *et al*., 2014) [14]. Due to its many existing applications and constant evolution into more innovative materials, flax has become a crop of increasing industrial interest in recent decades, especially with respect to the use of flax fibre as a composite reinforcement.

Dry matter accumulation depends on the interception of incident solar radiation by the crop canopy and also the efficiency with which it is used to produce biomass. The production and maintenance of leaf area are the key factors affecting solar radiation interception. Nitrogen application has significant influence on both leaf area development and leaf senescence (Novoa and Loomis, 1981; Muchow, 1988) [12]. Therefore, photosynthetic activity of the leaf varies with leaf nitrogen content. Nitrogen is a component of protein and nucleic acids and thereby has important role in leaf expansion. However, excess application of nitrogen results in lodging of flax at harvest. Application of phosphorus and potassium can suppress such adverse effect of excess nitrogen. Again, phosphorus has major role in cell division because it is a component of nucleoproteins which are involved in the cell division processes (Gul *et al*., 2015) [6]. Potassium is essential for a number of metabolic functions such as enzyme activation, protein synthesis, photosynthesis, osmoregulation, stomatal movement, energy transfer, phloem transport, cation anion balance and stress resistance. Therefore, balanced nutrition of nitrogen, phosphorus and potassium is essential for optimum leaf area index of flax which ultimately leads to efficient photosynthesis and plant growth.

Besides leaf area, chlorophyll content in leaves also affects photosynthetic activity of plants. Chlorophyll content is an important indicator of plant health and can be used to optimize nitrogen application to enhance the crop yields with less environmental load. Among the primary nutrients, nitrogen is a key component of the chlorophyll molecule and also is part of the enzymes associated with chlorophyll synthesis (Hokmalipour and Darbandi, 2011) [8]. So, the concentration of nitrate available to a plant directly influences chlorophyll biosynthesis and chloroplast development. It has also been recognized that potassium deficiency results in reduced plant growth and also adversely affects leaf metabolism such as altered carbohydrate concentrations and decreased rates of photosynthesis and translocation. Whereas, higher potassium nutrition promotes chlorophyll synthesis and better utilization of harvested light energy (Lamrani, 1996) [10].

Earlier, the effect of nitrogen, phosphorus and potassium on leaf growth and chlorophyll content were investigated in different crops however, literatures are limited regarding this aspect in fibre flax. Therefore, a study was conducted at G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India to evaluate the effect of combined effect of nitrogen, phosphorus and potassium on leaf area index and chlorophyll content of fibre flax which indicates healthy plant growth and development required for better yield of quality fibre.

## Materials and methods

The experiment was carried out during *Rabi* season of 2020-21 and 2021-22 at Norman E. Borlaug Crop Research Centre of G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India, located at 29° N latitude, 79.3° E longitude and an altitude of 243.8 m above mean sea level. The soil of the experimental site was sandy loam with near neutral pH (7.2), medium soil organic carbon (0.69%), low available nitrogen (195.7 kg/ha) and medium available phosphorus (19.9 kg/ha) and potassium (202.6 kg/ha). The experiment was carried out in Randomized Block Design with thirteen treatments replicated three times with a suitable plot size was of 6 m × 4 m. The treatments used for this experiment were 60:30:30, 60:30:45, 60:45:30, 60:45:45, 90:30:30, 90:30:45, 90:45:30, 90:45:45, 120:30:30, 120:30:45, 120:45:30, 120:45:45 kg/ha $N:P_2O_5:K_2O$ and control (no NPK application). Phosphorus and potassium in full dose with half dose of nitrogen was applied as basal during sowing. The rest amount of nitrogen was used as top dressing in two equal splits at 30 and 50 DAS. For leaf area index (LAI) and chlorophyll content, sampling of flax was done at 60 and 90 DAS. In case of LAI, flax plants of 1 m row length were cut and leaves were categorized in small, medium and large group followed by counting the respective number of leaves in each group. Thereafter, five representative leaves were taken randomly from each group and put on the millimetre graph paper to measure their actual leaf area and mean leaf area of each group was calculated. Finally average leaf area per plant was determined. The number of plants sampled from 1 m row length was counted and based on the number of plants present, leaf area index was calculated by the following formula:

$$\text{LAI} = \frac{\text{Total leaf area}}{\text{Ground area}}$$

Leaf chlorophyll content was analysed by DMSO method (Hiscox and Israelstam, 1979; Paul, 2017) [7, 13] in which 100 g finely chopped fresh leaf samples were taken in a test tube and 20 ml DMSO was added. After incubation of the set up at 65 ºC for 5 hours, absorbance of the extracted solution was taken at 663 and 665 nm. Total chlorophyll content was calculated by using the following formula:

$$\text{Total chlorophyll (a + b) (mg/g FW)} = [(8.02 \text{ x } A_{663}) + (20.2 \text{ x } A_{645})] \times \frac{V}{1000 \times W}$$

Where, A = Absorbance at given wavelength, V = Final volume of DMSO in ml and W = Weight of plant tissue in gram (g).

## Results and discussion

### Leaf area index (LAI)

Addition of NPK significantly influences LAI at both the crop growth stages. LAI under fertilizer application was significantly higher as compared to control. At 60 DAS, all the combinations of NPK resulted in significantly higher LAI as compared to the lowest NPK dose (60:30:30 kg/ha $N:P_2O_5:K_2O$). Excluding control, the value of LAI varies from 2.56-3.25 and 2.29-3.18 during 2020-21 and 2021-22, respectively (Table 1). At 90 DAS, the highest LAI (3.91 and 3.76 in both the years, respectively) was recorded with application of 120:45:45 kg/ha $N:P_2O_5:K_2O$ which was closely followed by 90:45:45 kg/ha $N:P_2O_5:K_2O$ and were statistically similar to the treatments of 90 kg N/ha with different combinations of phosphorus and potassium doses. Under same $P_2O_5$ and $K_2O$ level, increase in nitrogen application from 60 to 90 kg/ha significantly improve LAI of flax and further increasing nitrogen dose could not produce statistically significant results. Kakabouki *et al*. (2021) [9] also had found positive correlation between LAI and nitrogen fertilization. Nitrogen has important role in nucleic acid and protein synthesis (Carpici, 2011) [2]. Therefore, nitrogen enhances plant cell enlargement, leaf area development and participates in photosynthetic activity which was reported by Abd Eldaiem *et al*. (2015) [1].

**Table 1:** Effect of different NPK dose combinations on leaf area index of flax during 2020-21 and 2021-22

| Treatments | LAI | | | |
|---|---|---|---|---|
| | 60 DAS | | 90 DAS | |
| | 2020-21 | 2021-22 | 2020-21 | 2021-22 |
| $T_1$ (60:30:30) | 2.56 | 2.29 | 3.06 | 2.71 |
| $T_2$ (60:30:45) | 3.04 | 3.02 | 3.10 | 2.93 |
| $T_3$ (60:45:30) | 3.02 | 2.96 | 3.09 | 2.88 |
| $T_4$ (60:45:45) | 3.07 | 3.04 | 3.21 | 3.23 |
| $T_5$ (90:30:30) | 3.10 | 3.01 | 3.62 | 3.45 |
| $T_6$ (90:30:45) | 3.14 | 3.09 | 3.60 | 3.57 |
| $T_7$ (90:45:30) | 3.09 | 3.04 | 3.62 | 3.48 |
| $T_8$ (90:45:45) | 3.17 | 3.24 | 3.85 | 3.73 |
| $T_9$ (120:30:30) | 3.12 | 3.09 | 3.69 | 3.46 |
| $T_{10}$ (120:30:45) | 3.18 | 3.19 | 3.75 | 3.59 |
| $T_{11}$ (120:45:30) | 3.19 | 3.16 | 3.69 | 3.63 |
| $T_{12}$ (120:45:45) | 3.25 | 3.18 | 3.91 | 3.76 |
| $T_{13}$ (Control) | 1.90 | 1.66 | 2.31 | 2.10 |
| SEm± | 0.147 | 0.159 | 0.159 | 0.179 |
| LSD (p=0.05) | 0.429 | 0.465 | 0.464 | 0.524 |

**Total chlorophyll content**

In the two years study (2020-21 and 2021-22), NPK dose variation resulted in considerable effect on total chlorophyll content of flax leaf as compared to the plants grown without fertilizer application (Fig. 1 and Fig. 2). The total chlorophyll content was the highest with application of 120:45:45 kg/ha $N:P_2O_5:K_2O$ having the value of 2.64 and 2.84 mg/g (on an average) at 60 and 90 DAS, respectively which was closely followed by 90:45:45 kg/ha $N:P_2O_5:K_2O$. Increasing the nitrogen rate from 60 to 120 kg/ha gradually enhanced the total chlorophyll content in both the years of experiment. Nitrogen is an important structural component of chlorophyll and also required for the enzymes involved in chlorophyll synthesis (Hokmalipour and Darbandi, 2011) [8]. Similar result was also documented by Chen *et al*. (2019) [3]. However, higher dose of phosphorus or potassium or both over 30 kg/ha at same nitrogen level did not exhibit remarkable difference in leaf chlorophyll content of fibre flax.

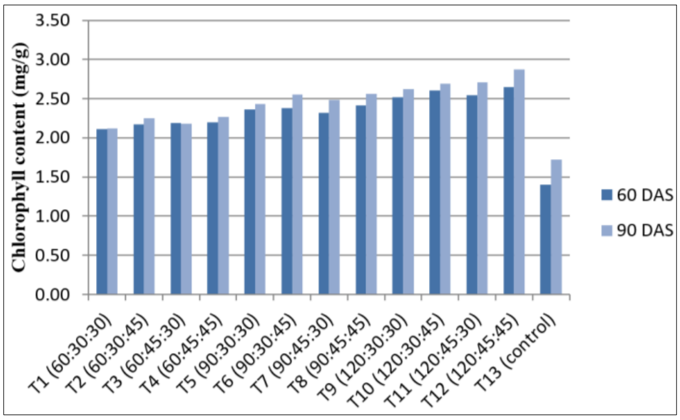


**Fig 1:** Effect of different NPK dose combinations on leaf total chlorophyll content in 2020-21

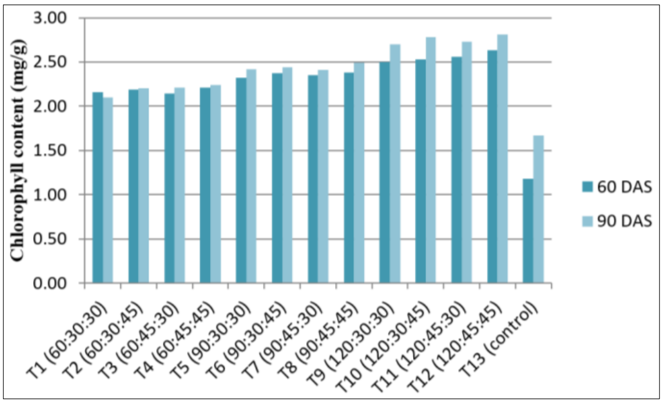


**Fig 2:** Effect of different NPK dose combinations on leaf total chlorophyll content in 2021-22

**Conclusion**

From the two years study, it can be concluded that application of 120:45:45 as well as 90:45:45 kg/ha $N:P_2O_5:K_2O$ can considerably improve leaf area index as well as total chlorophyll content of fibre flax which is essential for better plant growth and yield through efficient photosynthesis.

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