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# Impact of Row Ratio and Soil Fertility Management Strategies on Performance of Wheat + Linseed Intercropping System

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## ABSTRACT

**Background:** Intercropping with non-exploited crops is an emerging trend due to their adoptability to changing climatic conditions. There is a considerable scope to bring large area of Bulandshahr region, Uttar Pradesh under linseed through intercropping. The success of intercropping depends mainly on the use compatible crops and their suitable row proportion. The continuous application of inorganic fertilizers even in the balanced form may not sustain soil fertility and productivity. The aim of the present study is to find out the possibility of increasing the production of cereal and oilseeds through intercropping by adopting appropriate spatial arrangement of crops and nutrient management.

**Methods:** A field experiment was conducted at Bulandshahr (U.P.) on sandy loam soil for two consecutive years in split plot design with three replication having five main plot treatments (crop geometry) *viz.,* sole wheat, sole linseed, wheat + linseed (1:1), wheat + linseed (2:1), wheat + linseed (4:1) and four sub plot treatments (fertility levels) *viz.,* 5 t FYM/ha, 50% RD of NPK, 75% RD of NPK and 100% RD of NPK.

**Result:** The results revealed that the plant height at maturity, yields, harvest index, wheat equivalent yield (q/ha), uptake of nitrogen, phosphorus and potassium in grains and straw in wheat were significantly superior in sole wheat followed by wheat + linseed intercropping with 4:1 ratio. Likewise, fertility level of 100% NPK resulted into higher values of above mentioned parameters than their respective counterparts.

**Key words:** Economics, Intercropping system, Linseed, Row ratio, Wheat, Yield.

## INTRODUCTION

Wheat (*Triticum aestivum* L.) is an important cereal crop of Indo-Gangetic plains of India. Although Punjab and Haryana have highest wheat productivity at national level, Uttar Pradesh (UP) has maximum contribution to the national food basket in terms of total wheat production to the tune of more than 30% alone (Sharma *et al.,* 2020). UP state has uniqueness being part of three major mega zones namely North Western Plains Zone (28 districts of western UP), North Eastern Plains Zone (42 districts of central and eastern UP) and Central Zone (5 districts of Bundelkhand region). Among these, the areas under Bundelkhand region in Central Zone represent the marginal areas having low soil fertility and water stress conditions.

The high input based agriculture in present situation is showing signs of stress (Sanjay-Swami, 2020) and long term cereal based nutrients exhaustive crops are putting a question mark on long term sustainability, especially under dry land situations. As practiced from earlier days, intercropping is a useful proposition for increasing the productivity and income per unit area/time in agriculture besides enhancing the water and land use efficiency (Sanjay-Swami, 2021). Today intercropping with various non exploited crops are gaining importance due to their adoptability to changing climatic conditions prevailing in the region and for achieving higher returns under adverse conditions. This necessitates development of an appropriate intercropping technology for different crops especially minor crops which are grown on a limited area.

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Linseed is one among minor crops which is of economic value because of its common usage in animal feed, oil extraction, *etc.* The area under linseed crop cannot be increased because of the inflexibility of existing cropping systems. Hence, the only way to increase the productivity of such crops is to grow them in association with other crops in such a pattern that the productivity of the base crop is least affected by the associated crop and the production per unit area is also increased (Verma *et al.,* 2018). Plant population and spatial arrangement in intercropping have important effect on the balance of competition between the component crops and their productivity. Intercropping of oilseed with cereal crops is one of the ways to increase their production because intercropping is more advantageous than sole cropping of either of these crops (Padhi and Panigrahi, 2006). The greatest limitation in increasing the productivity of these crops is inadequate supply of nutrients, because the soils of Bundelkhand region are poor in native fertility (Singh and Khan, 2003). The continuous application of inorganic fertilizers even in balanced form may not sustain soil fertility and productivity. However, judicious use of chemical fertilizers in combination with organic manures is required to improve the soil health as well as to achieve sustainable crop production (Mankotia, 2007). Farmyard manure is the proven source of nutrition to agricultural crops. Thus balanced fertilization along with sound crop husbandry offers a great scope for increasing the productivity. The information on comparative performance, nutrient management, competition relations and sustainability of the system in Bundelkhand region is lacking. Keeping these aspects in view, the present investigation was planned to find out the appropriate row ratio and nutrient management strategy for wheat-linseed intercropping system.

## MATERIALS AND METHODS

A field experiment was conducted at A.S. College, Lakhaoti, Bulandshahr (U.P.) to find out the appropriate row ratio and nutrient management strategy for wheat + linseed intercropping system and to assess the effect of the same on the performance of wheat and linseed. The soil of the experimental site was sandy loam in texture and low in available nitrogen (257.8 kg/ha), medium in available phosphorus (13.68 kg/ha) and available potassium (162.6 kg/ha) and low in organic carbon (0.36%) contents with alkaline reaction (pH 7.4), respectively. The experiment was conducted in split plot design with three replications having five main plot treatments *viz.*; sole wheat, sole linseed; wheat + linseed (1:1) and wheat + linseed (2:1), wheat + linseed (4:1) and four sub plot treatments (fertility levels) *viz.*; 5 t FYM/ ha, 50% RD of NPK, 75% RD of NPK and 100% RD of NPK. Wheat and linseed were sown in rows 30 cm apart. Nitrogen, phosphorus and potassium doses were applied as per treatment through urea, single superphosphate and muriate of potash.

N, P, K in grain and straw samples were determined by standard procedures and then total uptake of N/P/K was calculated separately by the following formula:

$$\text{Uptake of N/P/K kg ha}^{-1} = \text{N\% P\% K\%} \times \text{Dry matter kg ha}^{-1} \div 100$$

Wheat equivalent yield was calculated using the following formula:

$$\text{WEY} = \text{Linseed yield (kg ha}^{-1}) \times \text{Price of linseed yield (Rs kg}^{-1}) \div \text{Price of wheat crop (Rs. kg}^{-1})$$

Protein content (%) in seed of linseed was determined by multiplying nitrogen content with the factor of 6.25. The protein yield kg ha$^{-1}$ was calculated from the mean seed yield multiplied by protein content of the corresponding treatment.

B.C. ration was calculated using the under mentioned formula:

$$\text{B:C ratio} = \frac{\text{Gross return (Rs. ha}^{-1})}{\text{Cost incurred in cultivation (Rs. ha}^{-1})}$$

## RESULTS AND DISCUSSION

### Plant height

The maximum plant height at harvest (80.06 cm) was recorded in sole wheat and it was statistically at par with wheat + linseed row ratio of 4:1, but significantly higher than

**Table 1:** Plant height, yield, harvest index, WEY and quality of wheat as influenced by row ratio and soil fertility management strategies under wheat + linseed intercropping system (Pooled data).

| Treatments | Plant height at harvest (cm) | Grain yield (q/ha) | Straw yield (q/ha) | Harvest index (%) | WEY (q/ha) | Protein (%) | Protein yield (q/ha) |
|---|---|---|---|---|---|---|---|
| | | Wheat | | | | | |
| **Cropping systems** | | | | | | | |
| W (pure) | 80.06 | 36.88 | 48.59 | 43.15 | 36.88 | 12.25 | 4.52 |
| L (pure) | - | 12.24 | - | - | 44.64 | - | - |
| $W_1$:$L_1$ | 76.87 | 27.85 | 39.98 | 41.06 | 39.90 | 12.25 | 3.41 |
| $W_2$:$L_1$ | 78.66 | 30.27 | 40.75 | 42.61 | 37.76 | 12.28 | 3.72 |
| $W_4$:$L_1$ | 79.27 | 34.90 | 43.05 | 43.18 | 40.97 | 12.34 | 4.32 |
| SEm± | 0.36 | 0.65 | 0.62 | 0.24 | 0.22 | 0.07 | 0.04 |
| CD (P=(0.05) | 1.02 | 1.98 | 1.79 | 0.69 | 0.64 | NS | 0.10 |
| **Fertility levels** | | | | | | | |
| 5t FYM/ha | 75.98 | 28.71 | 39.81 | 41.88 | 44.33 | 12.06 | 3.46 |
| $N_{50}$ $P_{30}$ $K_{20}$ | 78.18 | 30.57 | 42.56 | 41.81 | 48.80 | 12.16 | 3.71 |
| $N_{75}$ $P_{45}$ $K_{30}$ | 80.13 | 33.90 | 46.10 | 42.21 | 51.46 | 12.38 | 4.19 |
| $N_{100}$ $P_{60}$ $K_{40}$ | 80.52 | 36.81 | 48.05 | 43.38 | 54.53 | 12.53 | 4.61 |
| SEm± | 0.36 | 0.65 | 0.62 | 0.24 | 0.22 | 0.07 | 0.04 |
| CD (P=(0.05) | 1.02 | 1.98 | 1.79 | 0.69 | 0.64 | 0.19 | 0.10 |

**Table 2:** N, P, K uptake (kg/ha) and economics of wheat as influenced by row ratio and soil fertility management strategies under wheat + linseed intercropping system (Pooled data).

| Treatments | Nitrogen | | Phosphorus | | Potassium | | COC | GR | NR | BC |
|---|---|---|---|---|---|---|---|---|---|---|
| | Grain | Straw | Grain | Straw | Grain | Straw | | | | |
| **Cropping systems** | | | | | | | | | | |
| W (pure) | 72.25 | 24.05 | 7.55 | 4.60 | 20.1 | 96.40 | 18565 | 44952 | 26387 | 1.42 |
| L (pure) | - | - | - | - | - | - | 19684 | 52657 | 32973 | 1.68 |
| $W_1$:$L_1$ | 54.60 | 19.35 | 5.60 | 3.80 | 14.6 | 78.10 | 30880 | 51591 | 20710 | 0.67 |
| $W_2$:$L_1$ | 59.45 | 19.75 | 5.85 | 3.50 | 16.2 | 79.85 | 23177 | 46051 | 22874 | 0.99 |
| $W_4$:$L_1$ | 69.05 | 22.80 | 7.00 | 4.35 | 18.7 | 90.50 | 24403 | 50081 | 25677 | 1.05 |
| SEm± | 0.35 | 0.22 | 0.20 | 0.03 | 0.32 | 1.49 | - | - | - | - |
| CD 5% | 1.01 | 0.62 | 0.60 | 0.08 | 0.92 | 4.30 | - | - | - | - |
| **Fertility levels** | | | | | | | | | | |
| 5t FYM/ha | 55.40 | 18.70 | 5.45 | 3.15 | 14.8 | 77.40 | 22911 | 53957 | 31046 | 1.36 |
| $N_{50}$ $P_{30}$ $K_{20}$ | 59.40 | 20.40 | 5.95 | 3.60 | 16.05 | 83.20 | 20102 | 59189 | 39087 | 1.95 |
| $N_{75}$ $P_{45}$ $K_{30}$ | 67.10 | 23.00 | 6.95 | 4.55 | 18.5 | 90.80 | 19592 | 62826 | 43233 | 2.21 |
| $N_{100}$ $P_{60}$ $K_{40}$ | 73.80 | 24.50 | 7.70 | 5.00 | 20.4 | 95.35 | 13923 | 65896 | 51973 | 3.74 |
| SEm± | 0.35 | 0.22 | 0.21 | 0.03 | 0.32 | 1.49 | - | - | - | - |
| CD P=(0.05) | 1.01 | 0.62 | 0.60 | 0.09 | 0.92 | 4.30 | - | - | - | - |

other wheat + linseed row ratios (Table 1). The lowest plant height (76.87 cm) was recorded in wheat + linseed (1:1). Among the row ratios, wheat + linseed row ratio of 4:1 produced taller plants as compared to other row ratios. This may be attributed to the fact that plants with closer spacing tend to grow vertically due to competition for light and space as comparatively less space is available for horizontal (side ward) expansion. The similar results have been reported by Das *et al.* (2011), Alrijabo and Al-Healy (2014) and Zhang *et al.* (2015). However, under different fertility level, 100% NPK registered the highest plant height (80.52 cm) at maturity as compared to other fertility level.

## Yield

The highest grain yield (36.88q/ha), was recorded in sole wheat and it was statistically at par with wheat + linseed row ratio of 4:1, but significantly higher than other wheat + linseed row ratios (Table 1). The lowest grain yield (27.85 q/ha) was recorded in wheat + linseed (1:1). Similar trend was observed in straw yield (48.59 q/ha) and harvest index (43.15%). This might be due to the reason that total yield of any crop is the joint effect of its contributing characters such as crop stand, plant height, number of tillers, number of branching etc. All these attributes were favored appreciably in pure stand of the crops and therefore, resulted in higher yields. Among the row ratios, wheat + linseed row ratio of 4:1 produced highest grain and straw yield as compared to other row ratios. The optimum space as available for wheat plants under sole stand reduced the competition for moisture, nutrients and light among the wheat plants as compared to that as provided under other intercropping combinations might be responsible for the production of higher yield attributes of sole crop of wheat (Brij Nandan, 2015). Biradar *et al.* (2015) and Tanwar *et al.* (2011) have also expressed similar view in their studies. Among the fertility level 100% NPK recorded significantly higher yield as compare to other levels. This could be attributed to the higher fertility level which managed to support the combined demand of both the crops at optimum level (Meena *et al.*, 2018).

## Wheat equivalent yield

The yield of wheat and linseed crops taken in the wheat +linseed intercropping systems with different crop geometry was expressed as wheat equivalent yield and is presented in the Table 1. The wheat-equivalent yield of sole linseed recorded highest yield (44.64 q/ha) as compare to other treatments. Among intercropping treatments, significantly higher wheat equivalent yield was recorded in wheat + linseed with 4:1 ratio (40.97 q/ha) whereas lowest yield was recorded in sole wheat.

Among the fertility level, significantly higher wheat equivalent yield (54.53 q/ha) was recorded with 100% NPK fertilizer, while as lowest wheat equivalent yield (44.33 q/ha) was recorded in 5 t FYM/ha. This was because of high yield of pure wheat in W:L (4:1) and an additional yield of 1-2 quintals of linseed as a bonus.

Wheat based intercropping systems did not differ significantly in recording crude protein content (Table 1) of wheat. Under fertility level 100% NPK fertilizer recorded significantly higher crude protein content (12.53%). This non-significant variation in crude protein content of wheat might be due to the ineffectiveness of the different wheat based intercropping systems in influencing its per cent crude protein content. Significantly higher crude protein yield realized with sole wheat (4.52 q/ha) over wheat in wheat based intercropping systems, this might be due to the cumulative effect of large variation in the crude protein content and seed yield of wheat taken as sole crop as well as in the wheat in intercropping systems. The results are in close conformity with the results of Chadhuary *et al.,* (2002) and Singh and Rana (2005). Under different fertility levels, 100% NPK recorded significantly highest crude protein yield (4.61 q/ha).

**Nutrient uptake**

The sole wheat removed significantly higher amounts of N, P and K as compared to wheat grown in association with linseed with different ratios. The higher uptake of these nutrients by sole wheat as compared to intercropped wheat might be due to vigorous growth and better root system under optimum spacing which had helped in adequate supply of these nutrients resulting in higher biological yield coupled with numerically higher nutrient contents of N, P and K. These results are in accordance with those of Kheroar and Patra (2014). Among fertility levels, significantly highest N, P and K from grain and straw of wheat was removed from fertility level with 100% NPK application, respectively. The higher uptake of N, P and K by wheat at higher rates of NPK was reported by many workers (Sanjay-Swami *et al*., 2019; Gupta *et al*., 2019; Yadav *et al*., 2020).

**Economics**

The data given in Table 2 clearly indicated that pure linseed recorded highest B:C ratio (1.68). This was due to less cost of linseed cultivation as compare to wheat (1.42). The intercropping W+L (4:1) system obtained highest B:C ratio (1.05) than W+L (1:1) and W+L (2:1) systems on pooled basis over years. Among the fertility levels, it increased to maximum at 100% NPK level (3.74) followed by 75 and 50% NPK level in both the years. The results obtained by Kaushik and Sharma (2017) on monetary indices of wheat as influenced by intercropping and row proportions confirm the findings of this study.

## CONCLUSION

Based on the findings of present investigation, it is concluded that wheat + linseed intercropping system with 4:1 ratio, receiving 100% NPK is sustainable and remunerative for Bundelkhand region of Uttar Pradesh.

**Conflict of interest:** None.

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