# Yield indices and profitability of wheat + mustard intercropping as influenced by row ratio, compact mustard variety and fertilizer use.

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**Abstract**

With the development of compact mustard varieties ideally suited to intercropping there is the need to identify optimum row ratio and fertilizer use to achieve the maximum productivity and profit in wheat + mustard intercropping. A field experiment was conducted during winter seasons of 1999-2000 and 2000-01 at Varanasi to assess the effect of varying row ratio, mustard variety and fertility levels on various competitive functions in wheat (*Triticum aestivum* L.) + mustard (*Brassica juncea Czern & Coss* ) intercropping. The experiment was laid out in split plot design with three replications. The combinations of three wheat and mustard row ratios (8:1, 5:1 and 2:1) and two mustard varieties (Sanjucta Asesh and Vardan) were assigned to main plots. The sub-plot treatments were three fertility levels *viz*. 33.35, 66.6% and 100% of the recommended NPK dose to mustard with 100% recommended NPK to wheat. Sole crop of wheat (HUW 468) and the two mustard varieties were also taken for comparison. The results indicated that increasing row ratio of wheat: mustard from 2:1 to 8:1 caused marked improvement in partial LER of wheat, whereas the reverse trend was observed for mustard. The total LER at 8:1 and 5:1 row ratio though remained comparable, both recorded significantly higher LER than 2:1 row ratio. Relative crowding coefficient (RCC) also followed almost the similar pattern. Wheat was least competitive at 5:1 ratio at which the mustard was most aggressive. Nevertheless, 5:1 row ratio produced maximum wheat equivalent yield (WEY), which was significantly higher than 2:1 row ratio. Among the two varieties used in wheat + mustard intercropping, Sanjucta Asesh, a highly compact variety, produced significantly higher values in respect of partial LER of wheat, total LER, yield proportion of wheat, RCC of wheat (kwm), product of component RCCs (K), competitive ratio (CR) and aggressivity of wheat (Awm) than Vardan. As regards the fertilizer application, decreasing levels of fertilizer applied to mustard from 100% of recommended NPK to 33.3% resulted in marked improvement of RCC, CR and aggressivity of wheat as well as the yield proportion of wheat. However, it adversely affected the mustard in respect of RCC, CR and aggressivity. The total LER and K also followed the similar trend. Wheat + mustard intercropping in 5:1 row ratio with Sunjucta Asesh as mustard variety and no curtailment of fertilizer to mustard proved most productive and remunerative.

**Key words**:Economics, Fertility levels, mustard variety, Row ratio, Wheat + compact mustard intercropping, Yield indices.

Wheat (*Triticum aestivum* L.) and mustard (*Brassica juncea Czern & Coss*), respectively are the predominant grain and oilseed crops during winter in North India.. The productivity of these two crops has improved to a good extent during the last four decades in the country though it is still very low in the Ganges basin comprising Varanasi region. The major cause for low productivity in this region is their mixed cropping without proper proportion, genotype selection and indiscriminate use of fertilizers.

Due to greater competing ability of mustard, selection of mustard variety is more important than that of wheat. Recently two mustard varieties *viz*. 'Sanjucta Asesh' and 'Vardan' have been specially developed for intercropping. However, the information on their compatibility as an intercrop with wheat pertaining to optimum row ratio and fertilizer application under Varanasi conditions is still lacking. The present investigation was therefore undertaken to assess yield advantage and competitive functions of what + mustard intercropping grown under varying row ratio, mustard variety and fertility levels under irrigated conditions.

## Material and methods

Field experiments were conducted during winter seasons of 1999-2000 and 2000-01 at the research farm of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The soil was Ustochrept with pH 7.4, low in organic carbon (0.42%) and available nitrogen 210.0kg/ha) and medium in available phosphorus (14.40 kg P/ha) and potassium (172.12 kg K/ha). The experiment was laid out in split-plot design with 3 replications. The treatments comprised 3 row ratios of wheat and mustard (8:1, 5:1 and 2:1) and 2 mustard varieties ('Sunjucta Asesh' and 'Vardan') in main plots. The sub-plot treatments were three fertility levels *viz*. 33.35, 66.6% and 100% of the recommended NPK (90 kg N + 45 kg $P_2O_5$ + 45 kg $K_2O$/ha) to mustard with 100% recommended NPK to wheat (120 kg N + 60 kg $P_2O_5$ + 60 kg $K_2O$/ha). In addition to these 3 extra plots each for sole wheat ('HUW 468') and sole Indian mustard ('Sanjucta Asesh' and 'Vardan') were also taken in each replication for assessment of yield advantage and competition functions and were fertilized at 100% of their recommended dose. Full recommended doses of P and K along with 50% N was applied as basal to both the crops in sole as well as intercropping system. Rest 50% N to mustard was top dressed after 30 days of sowing. Whereas, in wheat, it was applied in two equal splits at tillering and ear emergence stages. Fertilizer application of both the crops was met through urea, DAP and muriate of

potash.

The crops were sown in second fortnight of November during both the years with 100, 5 and 3.5 kg seed/ha for wheat (HUW 468), 'Sanjucta Asesh' and 'Vardan', respectively. A row to row distance of 23 cm was maintained in wheat sole as well as in intercropping system. Whereas, in the same gross plot, inter row spacing of 36.5 cm kept for sole mustard. Intra row of spacing of mustard both under sole and intercropping was kept at 12 cm by thinning the extra plants in two steps at 15 and 25 days after sowing. The total rainfall received during the crop period was 17.7 and 11.0 mm in 1999-2000 and 2000-01 respectively. Therefore, four irrigations were given at critical stages of wheat. To evaluate the treatment effects, reciprocity functions viz., Land Equivalent Ratio (Willey and Osiru, 1972), Relative Crowding Coefficient (de Wit, 1960), Relative Crowding Coefficient (de Wit, 1960), Aggressivity (Mc Gilchrist 1965) and Yield proportion of wheat (Mead and Willey, 1980) were worked out. However, the monetary advantage was calculated as follows:

$$\text{Monetary advantage (US \$/ha)} = \text{Value of combined intercropped yield} \times \frac{\text{LER}}{\text{LER-1}}$$

**Table1. Effect of row ratio, mustard variety and fertility levels on yields, land equivalent ratio and yield proportion of wheat in wheat + mustard intercropping (pooled data of 2 years).**

| Treatment | Wheat grain yield (kg/ha) | Mustard seed yield (kg/ha) | Land Equivalent Ratio (LER) | | | Yield proportion of wheat [$L_w/(L_w + L_m)$] | Wheat Equivalent Yield (WEY) (kg/ha) |
|---|---|---|---|---|---|---|---|
| | | | Partial LER of Wheat ($L_w$) | Partial LER of Mustard ($L_m$) | Total LER ($L_w + L_m$) | | |
| ***Row ratio*** (Wheat: Mustard) | | | | | | | |
| 8:1 | 4750 | 404 | 0.869 | 0.212 | 1.081 | 0.804 | 5994 |
| 5:1 | 4114 | 628 | 0.753 | 0.331 | 1.084 | 0.695 | 6048 |
| 2:1 | 2803 | 919 | 0.514 | 0.486 | 1.000 | 0.514 | 5631 |
| CD(P=0.05) | 213 | 88 | 0.61 | 0.052 | 0.045 | - | 241 |
| ***Mustard variety*** | | | | | | | |
| 'Sanjucta Asesh' | 4109 | 582 | 0.752 | 0.334 | 1.087 | 0.693 | 5899 |
| 'Vardan' | 3669 | 720 | 0.672 | 0.351 | 1.023 | 0.657 | 5823 |
| CD (P = 0.05) | 174 | 72 | 0.050 | NS | 0.037 | - | NS |
| ***Fertility levels**** W + M | | | | | | | |
| 100% + 100% | 3821 | 729 | 0.700 | 0.385 | 1.085 | 0.645 | 6063 |
| 100% + 66.67% | 3895 | 649 | 0.713 | 0.341 | 1.053 | 0.677 | 5894 |
| 100% + 33.33% | 3951 | 574 | 0.724 | 0.303 | 1.027 | 0.705 | 5716 |
| CD (P = 0.05) | NS | 46 | NS | 0.023 | 0.036 | - | 177 |
| ***Sole vs. Intercrop*** | | | | | | | |
| 'Sanjucta Asesh (sole) | - | 1735 | - | - | 1.000 | - | 5337 |
| 'Vardan' (sole) | - | 2047 | - | - | 1.000 | - | 6297 |
| Wheat (sole) | 5467 | - | - | - | 1.000 | - | 5467 |
| Intercrop mean | 3889 | 651 | - | - | - | - | 5891 |
| CD (P = 0.05) | 405 | 114 | - | - | - | - | 314 |

*Recommended dose of N-$P_2O_5$-$K_2O$ kg $ha^{-1}$ (wheat: 120-60-60: mustard: 90-45-45)

## Results and discussion

*Effect of row ratios*

In wheat + mustard intercropping, increasing row ratio of wheat : mustard from 2:1 to 8:1, significantly increased the partial LER of wheat but reverse trend was observed for mustard (Table 1). This could be ascribed to the differences in the relative proportions of component crops in various row ratios. Yield proportion of wheat also showed increasing trend with increasing row ratio of wheat: mustard. However, the total land equivalent ratio which is the function of partial LER of wheat and mustard, was found comparable at 5:1 and 8:1 row combinations but both recorded significantly higher yield advantage over 2:1 row ratio. However, 2:1 row ratio was found least productive with 0.51 yield proportion of wheat. The poor performance of 2:1 row ratio could be attributed to drastic reduction in wheat yield caused due to aggressive mustard (Rahman, 1999).

The Relative Crowding Coefficients of component crops clearly showed that wheat produced less than expected but mustard being more aggressive, competitive and dominant, yielded more than expected (Table 2). Nevertheless, the product of coefficients of wheat and mustard 'K' which shows the yield advantage was lucidly higher at wider row ratios than 2:1 row ratio confirming the results obtained for total land equivalent ratio. The aggressive nature of mustard made it more competitive than wheat (Table 2). The aggressivity and competitive ratio of mustard were maximum at 5:1 row ratio of wheat + mustard intercropping followed by 8:1 and 2:1 row ratios. As the wheat dominated by mustard, its aggressivity and competitiveness at various row ratios were reverse to that of mustard and it proved least aggressive and less competitive at 5:1 row ratio. Bora (1999) also reported different competitive behaviour of wheat and rapeseed with varying sowing proportions.

**Table2. Effect of row ratio, mustard variety and fertility levels on relative crowding coefficient, competitive ratio, aggressivity and economics in wheat + mustard intercropping (pooled data of 2 years.**

| Treatment | Relative Crowding Coefficient (RCC) | | | Competitive Ratio | | Aggressivity | | Gross return US $ /ha | Net return US$ /ha | Monetary advantage US$ /ha |
|---|---|---|---|---|---|---|---|---|---|---|
| | W ($k_{wm}$) | M ($k_{mw}$) | System $K=k_{wm} \times k_{mw}$ | W | M | W | M | | | |
| ***Row ratio*** (W: M) | | | | | | | | | | |
| 8:1 | 0.83 | 2.13 | 1.78 | 0.53 | 1.95 | -0.93 | 0.93 | 986 | 629 | 74 |
| 5:1 | 0.69 | 2.52 | 1.69 | 0.46 | 2.23 | -1.09 | 1.09 | 988 | 634 | 77 |
| 2:1 | 0.55 | 1.94 | 1.04 | 0.54 | 1.92 | -0.69 | 0.69 | 910 | 564 | 0 |
| CD(P=0.05) | 0.04 | 0.32 | 0.16 | 0.05 | NS | 0.09 | 0.09 | - | - | - |
| ***Mustard variety*** | | | | | | | | | | |
| 'Sanjucta Asesh' | 0.83 | 2.09 | 1.716 | 0.56 | 1.82 | -0.77 | 0.77 | 964 | 612 | 77 |
| 'Vardan' | 0.55 | 2.32 | 1.288 | 0.46 | 2.25 | -1.03 | 1.03 | 959 | 607 | 22 |
| CD (P = 0.05) | 0.06 | NS | 0.134 | 0.04 | 0.28 | 0.07 | 0.07 | - | - | - |
| ***Fertility levels**** W + M | | | | | | | | | | |
| 100% + 100% | 0.65 | 2.63 | 1.68 | 0.44 | 2.32 | -1.13 | 1.13 | 987 | 631 | 77 |
| 100% + 66.67% | 0.69 | 2.17 | 1.49 | 0.51 | 2.01 | -0.89 | 0.89 | 962 | 610 | 48 |
| 100% + 33.33% | 0.73 | 1.82 | 1.33 | 0.58 | 1.76 | -0.68 | 0.68 | 935 | 587 | 25 |
| CD (P = 0.05) | 0.05 | 0.15 | 0.10 | 0.04 | 0.19 | 0.07 | 0.07 | - | - | - |
| ***Sole stand*** | | | | | | | | | | |
| 'Sanjucta Asesh' | - | - | - | - | - | - | - | 805 | 473 | - |
| 'Vardan' | - | - | - | - | - | - | - | 958 | 625 | - |
| Wheat | - | - | - | - | - | - | - | 924 | 563 | - |

*Recommended dose of N-$P_2O_5$-$K_2O$ kg/ha [wheat (W):120-60-60; mustard (M): 90-45-45]

*Effect of mustard varieties*

The two mustard varieties did not differ significantly in respect of partial LER of mustard in wheat + mustard intercropping (Table 1). However, it is interesting to note that they caused lucid variation on the partial LER of wheat. Wheat in association with 'Sanjucta Asesh' recorded significantly higher partial LER than its intercropping with 'Vardan'. This could be attributed to the less aggressive and competitive nature of the former than latter causing less competition for natural and applied resources. Consequently, significantly higher total LER of wheat + mustard intercropping was obtained with 'Sanjucta Asesh' than 'Vardan'. It is also clear that 'Sanjucta Asesh' as intercrop produced slightly better yield proportion of wheat than 'Vardan' that led to better production efficiency of the system in terms of total land equivalent ratio. This suggests that intercropping of mustard variety 'Sanjucta Asesh' with wheat not only results in higher yield proportion of wheat but it also leads to higher productivity of the system than the other variety 'Vardan' being more aggressive than 'Sanjucta Asesh', proved more competitive than 'Sanjucta Asesh' (Table 2). The product of the RCCs of component crops' K', further, indicated higher production efficiency of the system with 'Sanjucta Asesh' than 'Vardan'. This confirmed the results observed for total LER and suggests that 'Sanjucta Asesh' is more compatible than 'Vardan' for intercropping with wheat.

*Effect of fertility levels*

It is obvious from the data presented in Table 2 that the aggressivity of mustard significantly enhanced with increasing levels of fertilizer. This resulted in corresponding decline in the aggressivity of wheat mainly due to greater shading effect exerted by mustard at higher fertility levels (data not reported). As wheat was more aggressive and competitive at lowest fertility level, it recorded maximum yield proportion of wheat at lowest fertility level followed by medium and highest fertility levels. Mustard registered maximum partial LER at highest fertility level followed by medium and lowest fertility levels (Table 1). However, the partial LER of wheat did not differ markedly due to fertility levels and so the total LER followed the similar trend as the partial LER of mustard, though the difference was significant only between the highest and lowest fertility levels. The RCCs of component crops as well as their product' K' at various fertility levels, further confirmed the results of LER, indicating maximum yield advantage with the application of full recommended doses of NPK to both the crops and the lowest when fertilizer application to mustard was curtailed by 66.67% (Table 1 & 2). Similar results have also been reported by Verma *el al*. (1997).

*Sole vs. Intercrop*

The two mustard varieties performed quite differently in their sole stand and 'Vardan' produced 17.9% higher seed yield than 'Sanjucta Asesh' (Table 1). This was mainly due to longer duration and better yield potential of the former than latter. However, because of considerably lower plant population of mustard in intercropping; its yield was significantly lower than the sole stand of either of the varieties. Similarly wheat also produced significantly lower grain yield in intercropping system than its sole stand. Besides lower plant population, the more competitive and aggressive intercrop also contributed in lowering the wheat grain yield in intercropping.

*Economics*

Intercropping of wheat and mustard at 5:1 row ratio produced maximum gross return and net return closely followed by 8:1 row ratio and both registered higher returns than either of the mustard variety in sole stand as well pure crop of wheat (Table 2). Wheat + mustard intercropping in 2:1 row proportion also proved remunerative over sole crops of wheat and mustard variety 'Sanjucta Asesh'. This could be ascribed to the yield advantage realized in intercropping particularly at 5:1 and 8:1 row ratios as well as the higher market price of mustard. The higher monetary advantage obtained at 5:1 row ratio also signifies its better land equivalent ratio than other row arrangements. 'Sanjucta Asesh' as intercrop produced higher gross return and net return than 'Vardan'. Due to its compact growth and early maturity, the former was less aggressive and competitive than latter. Therefore, 'Sanjucta Asesh' in intercropping with wheat resulted in higher yield advantage and thereby distinctly better monetary advantage than 'Vardan'. Application of 100% recommended dose of fertilizer to both the component crops resulted in maximum gross and net return and the profitability was declined markedly with decreasing levels of fertilizer application to mustard. This suggests that in wheat + mustard intercropping, no curtailment of fertilizer in mustard is possible. The similar trend was observed for monetary advantage that could be attributed to the improvement in land equivalent ratio with increasing levels of fertilizer application to mustard and its better market price.

The results of the present investigation clearly demonstrate that wheat + mustard variety 'Sanjucta Asesh' intercropping in 5:1 row ratio and full recommended dose of fertilizer application to both the crops may be practiced to achieve better land utilization and high yield as well as profitability under irrigated eco-system of Varanasi.

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