In view of low productivity and poor crop establishment of yellow sarson at terai region of West Bengal, an investigation was undertaken during 2007-08 and 2008-09 at the instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal, India to study the effect of integrated nutrient management and seed soaking agro-chemicals on growth and yield of yellow sarson. The results obtained from this investigation are summarized below.

5.1 Effect of integrated nutrient management:

Excepting emergence, integrated nutrient management showed significant effect on improving all the growth variables of yellow sarson recorded under this study. Plant height, number of primary branches plant\(^{-1}\), leaf area index, leaf area duration, dry matter accumulation, crop growth rate increased markedly due to the application of 75% of the recommended dose, FYM, *Azotobacter* and P.S.B together over the sole application of chemical fertilizers and were closely followed by the application of 75% of the recommended dose, FYM and *Azotobacter* together. The crop receiving plant nutrients only from chemical sources showed poor growth.

Yield attributes of yellow sarson viz. number of siliqua plant\(^{-1}\), number of seeds siliqua\(^{-1}\), siliqua length and 1000-seed weight favourably influenced by the integrated nutrient management practices. Application of FYM, bio-fertilizers (*Azotobacter* and P.S.B.) along with chemical fertilizers after 25% curtailment of its recommendation caused significant increase in number of siliqua plant\(^{-1}\), number of seeds siliqua\(^{-1}\), siliqua length and 1000-seed weight over the application of 100% recommended dose of chemical fertilizers and were very close to those obtained with the application of 75% of the recommended dose, FYM and *Azotobacter*; 75% of the recommended
dose, FYM and P.S.B.; 75% of the recommended dose along with vermicompost.

Integrated nutrient management also showed significant effect on the physiological activities of the yellow sarson. Stomatal conductance, transpiration rate and net photosynthesis rate varied greatly with the maximum utilization of the CO₂ in the photosynthetic processes in the nutrient management treatment where 75% of the recommended dose of chemical fertilizer along with FYM, Azotobacter and P.S.B were applied over the plots where the crop received 100% recommended dose of chemical fertilizers.

Maximum dry weight of root plant⁻¹, average root diameter and total root length were also recorded with the combined application of 75% of the recommended dose of fertilizers, FYM, Azotobacter and P.S.B. in comparison to the plots where yellow sarson received nutrients only from inorganic sources.

Seed yield and stick yield were significantly influenced by the integrated nutrient management treatments. The highest seed yield and stick yield were obtained from the crop receiving 75% of the recommended dose along with FYM and both the bio-fertilizers, i.e., Azotobacter and P.S.B. It was closely followed by the nutrient management treatments where the crop received 75% of the recommended dose as a common component along with Azotobacter, P.S.B and vermicompost respectively. Compared to those treatments, lower seed and stick yields were obtained with the crop receiving either 100% recommended dose through chemicals or 100% recommended dose along with sulphur. No significant effect has been found on harvest index of yellow sarson due to integrated nutrient management practice used in this study. Highest value of oil yield of yellow sarson was also estimated with the integrated nutrient management treatment consisting 75% of the recommended dose along with FYM, Azotobacter and P.S.B, though the seed oil percentage was recorded highest in the treatment consisting 100% recommended dose and sulphur.
NPKS uptake by the yellow sarson crop increased considerably due to the combined application of organic matter, inorganic fertilizers and bio-fertilizers. NPKS uptake increased markedly due to application of 75% of the recommended dose, FYM, Azotobacter and P.S.B. This nutrient management practices also exerted highest residual effect on soil fertility reflecting a considerable increase in available nitrogen, phosphorus and potassium content with sustain available sulphur.

Cultivation of yellow sarson with the combined application of FYM and both the bio-fertilizers used in this study i.e Azotobacter and P.S.B along with 75 % of the recommended dose fetched the best net return and return rupee\(^1\) invested. Despite higher initial investment compared to the sole use of chemical fertilizers, the higher net return was recorded in combined treatment due to higher productivity.

5.2 Effect of pre-sowing seed soaking:

Significant differences in field emergence and in most of the growth attributes of yellow sarson due to different seed-soaking levels were noticed under this study. Seed soaking with 100ppm KH\(_2\)PO\(_4\) before sowing of yellow sarson showed better field emergence, produced taller plants, higher number of primary branches plant\(^{-1}\), greater leaf area index up to 60 days after sowing, better crop growth rate up to the growth period between 45-60 days after sowing than those obtained with 100ppm Na\(_2\)HPO\(_4\) and water soaked seeds, though in most of the observation on growth attributes results obtained with 100ppm KH\(_2\)PO\(_4\) soaked seeds were at par with those obtained from 100ppm Na\(_2\)HPO\(_4\) soaked seeds.

Number of siliqua plant\(^{-1}\), number of seeds siliqua\(^{-1}\), siliqua length of yellow sarson favourably influenced by the pre-sowing seed soaking practice. Seed soaking with 100ppm KH\(_2\)PO\(_4\) before sowing caused significant increase in
number of siliqua plant$^{-1}$, number of seeds siliqua$^{-1}$, siliqua length over the water soaked seeds and were very close to those obtained with the 100ppm Na$_2$HPO$_4$ soaked seeds. No significant effect has been found on the 1000-seed weight of yellow sarson due to pre-sowing seed soaking.

Pre-sowing seed soaking also showed significant effect on the physiological activities of the yellow sarson. Stomatal conductance, transpiration rate and net photosynthesis rate varied greatly with the maximum utilization of the CO$_2$ in the photosynthetic processes in the nutrient management treatment where the seeds were soaked with 100ppm KH$_2$PO$_4$ before sowing over the plots where the crop seeds were soaked with Na$_2$HPO$_4$ or water. In comparison to the water soaked treatment 100ppm Na$_2$HPO$_4$ also showed significant variations in crop physiological activities.

A remarkable role of pre-sowing seed soaking had been found in the root growth and development of yellow sarson plant. Soaking the seeds with 100ppm KH$_2$PO$_4$ recorded maximum value of root dry weight, root diameter and root length. It was closely followed by the treatment where the seeds were soaked with 100ppm Na$_2$HPO$_4$. Both the seed soaking treatments with agro-chemicals showed significant variation in root growth and development of yellow sarson over the water soaked seeds.

Seed yield and stick yield were significantly influenced by the pre-sowing seed soaking treatments. The highest seed yield and stick yield were obtained from the treatment where the seeds were soaked with 100ppm KH$_2$PO$_4$ before sowing followed by the seed soaking with Na$_2$HPO$_4$ over water soaking treatments. However, pre-sowing seed soaking has no significant effect on the harvest index of yellow sarson crop. Highest value of oil yield of yellow sarson was also estimated with the pre-sowing seed soaking treatment with 100ppm KH$_2$PO$_4$, though the seed oil percentage had no significant variation due to the seed soaking treatments.
Uptake of nutrients also influenced significantly due to the pre-sowing seed soaking. Maximum uptake of nitrogen, phosphate, potassium and sulphur by the yellow sarson crop were recorded where the seeds were sown after soaking in 100ppm KH$_2$PO$_4$, and it was closely followed by the treatment where 100ppm Na$_2$HPO$_4$ was used as seed soaking agro-chemicals. Both the agro-chemicals showed significant variation over water soaked seeds.

Cultivation of yellow sarson with water soaked seeds came out as less remunerative compared to agro-chemicals soaked seeds. Highest net return, return rupee$^{-1}$ invested were obtained through 100ppm KH$_2$PO$_4$ soaked seeds. It was closely followed by the other agro-chemical used in the study, i.e, 100ppm Na$_2$HPO$_4$.

There was no considerable variation in residual fertility studied after the harvest of yellow sarson due to pre-sowing seed soaking treatments.

5.3 Interaction effect of integrated nutrient management pre-sowing seed soaking:

Interaction effect of integrated nutrient management and seed-soaking had been found in the physiological activities of yellow sarson at 45 days after sowing. Highest values of leaf stomatal conductance, and net photosynthesis rate with better utilization of internal carbon-di-oxide were observed in the plots where the seeds were soaked with 100ppm KH$_2$PO$_4$ before sowing at the fertility level comprising 75% of the recommended dose along with FYM, *Azotobacter* and P.S.B.

Though no significant interaction effect had been found in crop productivity and economics of crop production, clarity in the effect of the two factors (fertility factor and seed soaking factor) had always been there. From those results it has been found that the yellow sarson crops raised at the fertility treatment comprising 75% of the recommended dose, FYM,
Azotobacter and P.S.B with the 100ppm \( \text{KH}_2\text{PO}_4 \) soaked seeds were more remunerative in terms of net return and return rupee\(^{-1} \) invested due to highest crop productivity.

**Conclusion:**

From the present study it may be concluded that the integrated nutrient management is essential for improving growth, photosynthetic activities, productivity, quality, net return, return rupee\(^{-1} \) invested, nutrient uptake by yellow sarson at the winter condition of the *terai* region of West Bengal. Integrated nutrient management is also beneficial for sustaining residual soil fertility at this zone. Application of 75% of the recommended dose + FYM + *Azotobacter* + P.S.B appeared to be optimum among the treatment combination used in this study. At this optimum level the yellow sarson crop produced seed yield of 1361 and 1387 kg ha\(^{-1} \), paid net return of ₹12643 and ₹12883 ha\(^{-1} \) and return rupee\(^{-1} \) invested ₹1.85 and ₹1.84 in the year 2007-08 and 2008-09 respectively. This optimum level of integrated nutrient management practice also exerted greater residual fertility after harvest of yellow sarson. Pre-sowing seed soaking also had an impact on emergence, growth, crop productivity, nutrient uptake and economics of yellow sarson cultivation. Seeds soaked with 100ppm \( \text{KH}_2\text{PO}_4 \) appeared to be the best among the seed soaking treatments.

As these two factors, integrated nutrient management and pre-sowing seed soaking, showed distinct effect on yellow sarson productivity and economics, a recommendation may come out in combination of both the factors.

In this study 75% recommended dose of chemical fertilizer, FYM, *Azotobacter*, P.S.B and sowing of seeds after soaking of seeds in 100ppm \( \text{KH}_2\text{PO}_4 \) came out as the best treatment among the treatment combinations used in the study at the *terai* region of West Bengal.