



Research Article

PROFITABILITY AND COST SAVING OF MUSTARD THROUGH ZERO TILL PLANTING FOR SUSTAINABILITY OF RICE-MUSTARD CROPPING SYSTEM IN COASTAL ODISHA

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Received: October 28, 2020; Revised: November 11, 2020; Accepted: November 12, 2020; Published: November 15, 2020

Abstract: Zero till planting an important component of conservation agriculture is found to be a potential alternative to conventional full tillage cultivation of mustard in north eastern coastal plain zone of Odisha. Farmers' participatory field trials were conducted to evaluate zero till cultivation along with different weed management practices against farmers' practices during 2014-15 and 2015-16 in mustard crop in rice-mustard cropping system. Maximum net return of ₹12750 per ha was obtained from ZT+Post herbicides significantly more than all other treatments. Grain yield and yield attributes of mustard were better under conventional tillage with line planting (T₃) over other practices. ZT treatments, ZT+Post and NS+ZT produced similar grain yield as obtained by farmers' practice of CT+BS (T₅). Even though CT+LS+BS (T₃) registered better grain yield, the net income (₹11289) was found to be lesser than that under ZT+Post (₹12750). Greater save in cost of cultivation and energy were observed under zero till planting with use of herbicide as post emergence or pre-plant application associated with higher profits. No till planting without herbicide application was found to be unprofitable during the experimentation period.

Keywords: Cropping System, Grain yield, Yield attributes, Zero till, Rice-mustard, Energy saving

Citation: Das A., et al., (2020) Profitability and Cost Saving of Mustard Through Zero Till Planting for Sustainability of Rice-Mustard Cropping System in Coastal Odisha. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 12, Issue 21, pp.- 10318-10320.

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Academic Editor / Reviewer: Dr B. S. Vyakarnahal

Introduction

In India, mustard is cultivated in 6.34 m ha with a total production of 7.82 mt and productivity of 1234 kg/ha. In Odisha, it is grown in about 0.145 m ha with a production and productivity of 0.6 million tons and 424 kg/ha (2013-14), respectively. Mustard and toria are major crops for sustainable intensification of rice-based cropping system in the state [1]. Mustard is cultivated mostly under temperate climates. It is also grown in certain tropical and subtropical regions as a cold weather crop [2]. Odisha is a non-traditional area for this crop so also this coastal plain zone. Toria (*Brassica rapa* var. toria) is preferred in irrigated coastal ecosystems of Odisha comprising districts of Bhadrak, Balasore, Jajpur, Puri and Ganjam. Short duration nature of this type of rapeseed mustard makes it suitable for cultivation under shorter length of growing season in rice-based cropping system.

The crop is cultivated mostly in low to medium land situation where long duration *kharif* rice is followed by toria / mustard in December which is considered as late sown for this crop. After the harvest of *kharif* rice, a minimum period of 15 days is taken for sowing of mustard; sometimes more time required when field is ploughed down with pre-sowing irrigation. Delayed planting results in more incidence of insect pests like aphid and spodoptera, poor grain filling due to prevailing high temperature and low yield. The crop associated with low profitability, low productivity, delayed planting, incidence of spodoptera, aphid, club root etc. for which the area under the crop is decreasing gradually. Low yield and associated low market price or distress sale lower the profitability. Even though mustard is a newer crop in this zone, still the area is declining due to low profitability making rice-mustard cropping system unsustainable.

Higher profitability can be achieved by increased production, minimization of cost of production and realization of better market price of mustard. Timely planting is the single most contributing factor and has the potential of increasing the yield significantly. Sharif *et al* (2016) [3] reported that, sowing time is an important factor for seed yield and quality in rapeseed. Timely sowing along with minimized cost of cultivation have the potential to maximize profitability. Analysis of various factors leading to increased cost of cultivation indicated tillage, weed management, pest management and harvest as the contributing factors. Early sowing would be possible with adoption of zero till planting which is an important component of conservation agriculture. Zero till is one of the most used resource conservation technology [4] which provides better economics in crop production [5]. The cost-benefit analysis in conservation agriculture (CA) based works involving ZT rice-ZT mustard revealed that CA practices fetched higher net returns by ₹53,000 and ₹21,400 ha⁻¹ from the rice-mustard system with and without summer mung bean, respectively over the transplanted rice-conventional till mustard system [6]. Similar increase in grain yield and net return in Indian mustard were found with ZT and crop residue management [7]. Weed management has also been recognised as an essential component of conservation agriculture [8]. Therefore, present investigation was carried out with the objective of studying effect of various crop establishment methods and weed management practices and their effect on yield and profitability under rice-mustard cropping system.

Materials and Methods

Farmers participatory research trials were conducted in farmers' field across the rice-mustard cropping systems of Bhadrak district (21.0126° N, 86.6208° E) coming under north eastern coastal plain zone of Odisha.

Table-1 Growth and yield attributes and seed yield of mustard under different zero till and conventional practices (mean of two years)

Treatment	Plant height, cm	No. of branches/plant	No. of siliqua/plant	No. of seeds/siliqua	Seed yield, t/ha
T ₁ : ZT + Post	102	8.4	74.6	9.4	0.75
T ₂ : NS + ZT	97	7.8	72.0	9.0	0.70
T ₃ : CT + LS+ Post	104	8.5	73.7	9.5	0.81
T ₄ : ZT	95	6.5	66.5	8.8	0.62
T ₅ : CT + BS	101	7.3	67.3	9.2	0.71
SEm±	3.48	0.37	2.41	0.2	0.025
CD 5%	8.5	0.9	5.9	0.5	0.06

Soils are mostly coastal alluvial, acidic to strongly acidic (pH 4.50-6.50) and normal in electrical conductivity (0.01-2.97 dS/m). Soil was medium in fertility with medium soil organic carbon (0.04-0.067 g/kg), low available nitrogen (58-114 kg/ha), medium in available phosphorus (9.0-16 kg/ha), low to medium in available soil potassium content (60-165 kg/ha). The climate of the district is tropical with five years (2014-2018) average rainfall of 1302 mm, 92 % of this received from southwest monsoon (May to October). The mean annual temperature is 33° C with average annual maximum and minimum of 42°C and 21.30°C, respectively.

The experiment was conducted in two villages in *rabi* seasons of 2014-15 and 2015-16. It comprised of 5 treatments viz. T₁: Zero till planting (ZT) + post emergent herbicide (Post), T₂: Pre-plant non selective herbicide (NS) + zero till planting (ZT), T₃: Conventional tillage (CT) + line sowing (LS) + post emergence herbicide (Post), T₄: Zero till planting with no herbicide (ZT), and T₅: Conventional tillage (CT) + broadcast sowing (BS). These five treatments were replicated in 5 farmers' field in two villages. Each of the plots were of 1000-2000 m² size as per farmers' convenience. Rice crop was grown in *kharif* followed by toria in *rabi* season under canal irrigation condition. The *kharif* rice of medium duration was taken in all those selected medium land experimental plots. Rice crops was harvested during second week of November which is the usual time of planting of toria in coastal district of Odisha in rice-mustard cropping system. Mustard crop for treatments under zero till planting (T₁, T₂, T₄) was sown at optimum soil moisture condition which was obtained after 5-10 days after harvest of rice crop. Sowing of mustard crops for the treatments T₃ and T₅ under conventional system were undertaken with pre-sowing irrigation as done by farmers. Farmers usually sow crops 15-30 days after harvest of rice after cultivating the field by conventional tillage with pre-sowing irrigation. However, in this trial sowing time for all were kept similar so as to eliminate effect of different dates of sowing on crop performance. Conventional tillage in T₃ and T₅ constituted of one primary tillage followed by one secondary tillage with the use of tined cultivator. In T₃ line sowing was done using seed cum fertilizer drill. T₅ is the practice adopted by farmers in which seed is sown by broadcast method using a higher seed rate of 10 kg/ha. Zero till planting in respective treatments were carried out using seed cum fertilizer drill with fluted roller seed metering mechanism with a lower seed rate of 7 kg/ha. Quizalofop ethyl 5 EC @0.05 kg/ha was applied in T₁ and T₃ plots as post emergent herbicide at 15-20 days after sowing. In T₂, non-selective herbicide Glyphosate 41 SL was applied @ 1 kg ai/ha 2 days before sowing of mustard. No other weed control measures were followed in these treatments.

Standard crop management practices were adopted in all the treatments. Recommended fertilizer dose of 60-30-30 kg N-P₂O₅-K₂O/ha was followed in all cases. Except in T₅, fertilizers were applied along with seeding using seed cum fertilizer drill in all treatments. NPK fertilizer 10-28-28 was mixed with mustard seeds in appropriate proportion and sown by seed cum fertilizer drill. Fertilizer application in T₅ was given following farmers' practice of application at 15-20 days after sowing at the time of first irrigation. Growth and yield parameters, such as plant height, number of branches, number of siliqua per plant and number of seeds per siliqua, were recorded from 10 randomly selected plants from each treatment plots. Energy consumption in tillage were calculated referring the standard energy usage given by Parihar *et al*, 2013 [9]. Gross return, net return and cost saving were calculated based on the prevailing local market price of grain and stover in 2014-15 and 2015-16. Net return was calculated by deducting cost of cultivation from gross return. Saving in cost of cultivation in various practices were estimated by comparing with cost of cultivation of farmers' practice (T₅)

Data were put to statistical analysis of variance as described by Gomez and

Gomez, 2010 [10]. Comparison of various treatments were done by calculating critical difference (CD) and expressed at 5% significance level (P=0.05).

Results and discussion

Results presented in [Table-1] revealed that, various treatment did not effect height of mustard plant except T₃ i.e., CT+LS+Post, increased plant height significantly more than that of T₄. Zero till without herbicide application (T₄) produced shorter plants, which is due to greater weed competition posed under no weed management conditions. All zero till planted treatments have effect on plant height at par that with farmers practice (T₅). It suggests about no adverse effect of zero till on mustard plant growth. Similarly, the other growth parameter, the branches/plant of mustard in all zero till treatments were either better than or at par with the farmers' practice (T₅). ZT with Post and CT+LS+Post produced higher number of branches than other treatments. ZT + Post herbicide was at par with CT+LS+Post which registered maximum number of branches per plant.

Number of siliqua/plant and number of seeds/siliqua were different due to various treatments. Siliqua numbers were significantly more under ZT+Post and CT+LS+Post treatments over the farmers' practice of CT+BS. Zero till without weed management (T₄) produced significantly less numbers of seeds per siliqua than CT+LS+PO. It indicates, weed management is an important factor under zero till condition affecting this yield attributing parameter significantly.

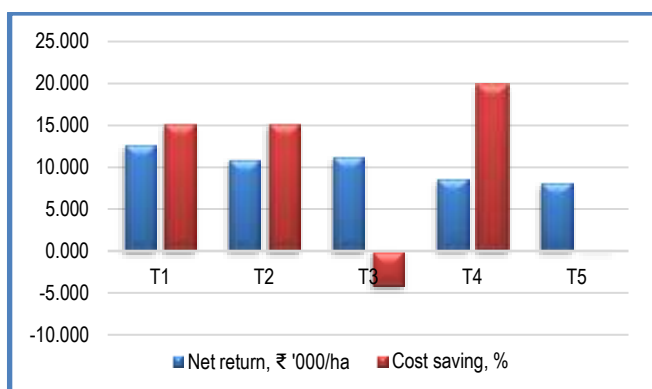


Fig-1 Net return, ₹/ha and cost of saving, % of various zero till and conventional practices in mustard (mean of two years)

Seed yield of mustard was maximum (0.81 t/ha) under CT+LS+Post significantly more than all other treatments. Two ZT treatments viz. ZT+Post and NS+ZT too registered significantly higher yield than other ZT option i.e., ZT without weed management (T₄) and produced at par yield as obtained from farmers' practice (T₅). It reveals that, with the adoption of ZT planting along with weed management is not adversely affecting the grain yield over the existing farmers' practice. At Bhubaneswar line sowing of mustard under zero tillage after rice gave maximum seed yield and oil content as compared to conventional tillage. As reviewed by Bhanu *et al*, (2019) minimum tillage, with or without straw, enhances soil moisture conservation and moisture availability during crop growth which results in increased root mass, yield components and seed yield. Zero tillage conserves better moisture in the soil profile all through the early growth period and thus may be preferred in mustard [11]. However, ZT planting without weed management strategy reduced grain yield to minimum (0.62 t/ha) which is even significantly lower than farmers' practice. Yield advantage along with reduced cost of cultivation will enhance the profitability under ZT technology which has been discussed in following sections.

Economics of any farm activities or practices is the most important consideration for a farmer for its adoption. The results of economic analysis presented in [Table-1] and [Fig-1] indicated that, the highest gross return of ₹31189 was registered by CT+LS+Post followed by ZT+Post with ₹28950 per ha. However, the maximum net return of ₹12750 per ha was obtained from ZT+Post which was significantly more than all other treatments including the treatment which registered maximum gross return. Gross return from farmers' practice (T_5) was ₹27277 and the associated net return was minimum among all treatments. Reduced cost of cultivation was calculated in terms of saving in cost (%) of all treatments as compared to the cost incurred in farmers' practice (T_5). Analysis of save in cost and corresponding net return depicted in [Fig-1] signifies the relationship of ZT with reduced cost of cultivation. Even though maximum saving in cost (19.9%) happened under ZT with no herbicide, the associated net return (₹8632) was very low. The decreased net return ascribed to low grain yield because of non-adoption of any weed management practices. On the other hand, two other ZT treatments have same savings in cost i.e., 15.2% but ZT with Post had higher net return of ₹12750 than treatment with ZT+Pre-plant application (₹10976) suggesting post application under ZT situation is the better weed management option. T_3 with CT+LS+Post involved marginally more cost than that in farmers' practice, whereas the net income was significantly higher than T_5 . It suggests, improvement of farmers' practice with line sowing and post herbicide could increase net return by ₹3112/ha over FP. The save in cost of cultivation under ZT practices is due to reduced tillage activity and associated energy use in the operation. Similar findings of economic advantage were reported by Monika *et al.*, (2014) [12] in mustard, and Tripathi *et al.*, (2006) [13] and Singh *et al.*, (2011) [14] in wheat. All ZT treatments had minimum energy use i.e., 396 MJ/ha as compared to CT which utilized maximum energy of 1525 MJ/ha in T_3 and 1130 MJ/ha in T_5 . Minimum tillage operations reduced the cost of cultivation in all ZT treatments which are important practices of conservation agriculture. The conventional system of seeding in mustard required 4.34 time more energy compared to ZT system as studied by Parmanand and Verma, (2017) [15]. Teja and Duany, (2018) reported that, after two cycles of conservation agriculture-based rice-mustard-green gram cropping system, conservation tillage with recommended herbicides and one hand weeding resulted in higher seed yield of mustard. Saving in time, cost of production and energy has greater positive impact on income and environment on long term.

Conclusion

It is evident from the results, ZT planting is not adversely affecting performance of mustard production, rather it produced yield at par that under farmers' practices. On the other hand, ZT is saving energy and cost involved in crop production. Further, it ensures early planting of mustard saving at least 25 days. In this experiment, since the time of planting was kept similar, the adverse effect of delayed sowing as adopted by farmers was not realized. The multiple advantages of ZT on production, economics, conservation of energy and time conclude that, this technology can be a suitable alternate to farmers' practices making rice-mustard cropping system profitable and sustainable. As such ZT planting with post emergence herbicide application can be recommended for higher profitability and resource conservation in mustard in north eastern coastal zone of Odisha.

Application of research: Zero till planting with proper weed management strategy as resulted from the experiment has been recommended to the agriculture department of Bhadrak district of Odisha for dissemination of the technology. This technology can also be recommended to other areas with similar agro-ecological situation. The findings will help other researchers to take up further studies in resource conservation technology in mustard in rice-mustard cropping system.

Research Category: Cropping system

Abbreviations: BS: Broadcast sown, CA: Conservation Agriculture
CT: Conventional tillage, EC: Emulsifiable Concentrate
LS: Line sown, mt: Million ton, NS: Non selective herbicides

Post: Post emergence application, Pre plant: Pre plant application of herbicide
SL: Soluble liquid, mt: Million ton, ZT: Zero till

Acknowledgement / Funding: Authors are thankful to ATMA, Bhadrak for providing funds for conducting farmers' participatory trials. Authors are also thankful to ICAR- Krishi Vigyan Kendra, Bhadrak, 756111, Odisha University of Agriculture & Technology, Bhubaneswar, 751003, Odisha, India

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Research project name or number: ATMA-KVK convergence Project

Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Village1: Khirasahi, Block: Bhadrak, Bhadrak. Village2: Barunei, Block: Tihidi, Bhadrak, Odisha

Cultivar / Variety / Breed name: M-27

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Ethical Committee Approval Number: Nil

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