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On-farm research trials in mushroom farming: technology assessment and constraint based recommendations

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ABSTRACT

On farm research (OFR) is the most reliable tool to test the technologies for their testing, validation and promotion. Such OFR trials provide an excellent opportunity to compare the performance of the proposed system and farmer's traditional practice in a reliable way. The objectives of the present research were to test the technologies related to mushroom, identify the constraints experienced by the farmers and to elicit the suggestions to overcome them. Five technologies were tested and all the five technologies were found to give better result over the existing ones with varying degree of success. The technologies in mushroom farming will prove significant in raising the farmers' income. Implementation constraints, climate and crop management practices demanded further precision. The quality of shiitake mushrooms needs to be addressed through genetic improvement studies. The non-technological problems such as marketing and value addition also surfaced after the trails. The OFR trials helped in promoting the diverse mushrooms in non-traditional areas to expand the availability of edible mushrooms to the consumers.

Key words: On farm research, technology assessment, mushrooms, *Agaricus, Lentinula, Volvariella, Macrocybe, Calocybe*

On-farm research (OFR) is an indispensable tool for developing and validating any farm technology. On-farm research can be defined in its simplest terms as research carried out on farmer's field and in a farmer's environment (Atta-Krah and Francis, 1987). While on-station research is necessary to screen and evaluate and to experiment with management practices, quick initiation of on-farm research will help the research and development process. The on-farm research plays essential roles in testing and validation of technologies developed by research/ experiment station under local farmer's conditions, development and adaptation of technologies for local farmers' conditions and demonstration and extension of technologies in local farming communities.

The best performing technology rarely performs at the same level on farmers' field. On-farm research is a means to ensure that technologies developed at research station will be relevant to the problems and priorities of the targeted client adopters. To validate on-station results, OFR is carried out to assess the performance of particular technologies on-farm with the farmer's involvement. Such research, in all likelihood will lead to the observation of yield gaps or shortfalls. Research is then aimed at identifying constraints, causing the gaps and eliminating or narrowing the gaps. On-farm trials allow assessment of the system according to a broad range of criteria. Analysis of such trials should be based not only on productivity and profitability, but also on all other

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factors that are likely to influence the acceptability of a technology to the farmer. These may include farmers' resources, the community's economic and social infrastructure, etc.

For any new technology or technology component to be accepted by farmers, it has to be shown to be superior to the existing system. The most reliable means of proving this is through OFR, in which the farmer is involved and the trial is run within the farm environment. Such OFR trials provide an excellent opportunity to compare the performance of the proposed system and farmer's traditional practice in a reliable way. With this background, the technologies developed on mushrooms by ICAR- Directorate of Mushroom Research were selected for the OFR trials at different farm situations across the country. The research had the objectives of; testing the technologies, identifying the constraints experienced by the farmers in adopting the new technologies and to elicit the suggestions to overcome them.

MATERIALS AND METHODS

The present OFR trials were conducted by the ICAR-Directorate of Mushroom Research, Solan in the year 2016-17 at different mushroom growing units belonging to farmers and entrepreneurs of the country. All the technologies selected for on farm trial were developed at ICAR-DMR as it has the mandate of evolving the new technologies for the farmers' benefit. Out of the technologies developed by the research institute, five potential technologies have been identified for the on farm research testing to assess the performance of these technologies in the farmers' field conditions. The five technologies identified for the project are;

i. Non browning strain of white button mushroom *(Agaricus bisporus)*
ii. Short duration cultivation technology of shiitake mushroom *(Lentinula edodes)*
iii. High yielding strain of *Macrocybe* mushroom *(Macrocybe* sp)
iv. High yielding strain of milky mushroom *(Calocybe indica)*
v. High yielding strain of paddy straw mushroom *(Volvariella volvaceae)*

New varieties and technology in mushrooms: Basis of selection

Yield evaluation tests have been carried out for the five browning resistant hybrids (NBS- 1, NBS-2, NBS-3, NBS-4 and NBS-5) of *Agaricus bisporus* on large-scale cultivation trials two times. In both the trials, each of hybrids was tested, on 1000 kg compost along with two controls U- 3 and DMR-03. Out of the five hybrids tested, two performed very well at DMR, Solan (Annual Report, 2014-15 ICAR-DMR, Solan). Of the good performing hybrids, NBS-1 and NBS-5 was selected for OFT in the present project.

The initial evaluation trial for paddy straw mushroom conducted at comparatively lower temperature conditions, revealed lowest first harvest time of 11.93 days in white strain, GVv- 01. It also gave the highest fruit body yield (20.79 kg/q dry substrate) and the mean fruit body weight (20.74 g) compared with four high yielding brown strains of *Volvariella volvacea.* The study proved the white strain as superior strain in all respects giving the first harvest nearly two days earlier, and fruit body yield and mean fruit body wt. higher by nearly 28 and 37%, respectively than the best performing brown strain (BBSR-007). This strain also revealed its ability to give superior fruit body yield at lower temperature conditions, where the high yielding brown strains failed (Annual Report, lCAR-DMR,Solan 2014-15).

A short duration cultivation technology for shiitake cultivation developed. Using this technology the first crop/harvest can be taken just in 45 days as compared to 75-80 by earlier available technology. Further, five strains (DMR-Shiitake-388S, DMR-Shiitake-388, DMR- 38, DMR- 16 and DMR- 22), of shiitake were evaluated. DMR-Shiitake-388S gave fruiting in the shortest duration (44 days). Shiitake -388 also took 52 days whereas other strains took more than 65 days for fruiting on sterilized saw dust substrate (Annual Report, ICAR-DMR, Solan 2014-15).

Five strains of *Calocybe indica* namely CI-14-0 I, CI-14-02, Cl-.14-03, CI-14-04 and Cl-14- 05 were evaluated for yield using chemically treated wheat straw at ICAR-DMR. CI-14-03 gave the highest yield (57.86kg/ q substrate) followed by CI-l4-02(42.l3kg/

q substrate) and CI-14- 01(32.80 kg/q substrate) (Annual Report, ICAR-DMR, Solan 2014-15).

Research design: Experimental design was adopted to test the technology in the OFR. The technology of the ICAR-DMR, Solan will be evaluated against the technology being presently used by the farmer/ entrepreneurs.

Sampling: Each of the five technologies will be tested in five trials spread over two years. Two to three farmers' field were selected for laying out the trials.

Generalisation: The results of the project can be generalised for the farmers with similar agro ecological and socio-psychological conditions.

(a) Instrumentation: The measuring instrument was developed to elicit the comparative data on feedback on the performance of technology with respect to biological efficiency and quality.

(b) Analytical tools: The data collected over the developed instrument will be analysed using the descriptive statistical methods.

RESULTS AND DISCUSSION

Technology adoption and lay out of trials

The farmers, who were willing to adopt the technologies of ICAR-DMR, were included to conduct the on-farm trials. The trainees who graduated from different training programmes of ICAR-DMR, farmers and entrepreneurs who purchased the spawn or got the project reports from DMR and beneficiaries under the *Mera gaon mera gaurav* (MGMG) scheme were included as adopters of the technology. Farmers/ entrepreneurs identified for on-farmtrials are listed in the table 1.

Performance of technologies in the farmers' field conditions

The technologies tested were recorded on the level of performance to the existing varieties in case of active growers and expected levels in respect of the new mushroom growers. For all the technologies, yield and quality were tested whether the new technology is performing lower, on par or higher than

Table 1. Farmers identified for adoption of technologies of ICAR-DMR, Solan

Sl. No.	Technology	Name and Address
1	Non browning strains of white button mushroom (*Agaricus bisporus*)	(i) Shrikar Kulkarni, Po: Tigadi, Tq: Bailahongal, Dt: Belgaum, Karnataka (ii) Arun Krishnamurthy, Oorgam, KGF, Kolar Dist, Karnataka (iii) Sh. Ram das Shinde, Tirupati Balaji Mushroom, Pune (iv) Flex Foods Ltd, Lal Tappar, Haridwar Road, Dehradun
2	Short duration cultivation technology of shiitake mushroom (*Lentinula edodes*)	(i) Gian Chand Kashyap, Viii: Shalog, Po: Syri, Tehsil Kandaghat, Dist: Solan (ii) Sh. Vikas Benal, Vill: Shamlaich, Dt: Solan (iii) Harikishan, Village: Dharot, Dist: Solan (HP)
3	High yielding strain of milky mushroom *(Calocybe indica*)	(i) Yunus Indikar, M.V. Nagar, BEML Nagar, KGF, Kolar Dt. Karnataka (ii) Raj Bahadur Jandial, S/o Sh. Bodh Raj Jandial, PO; Thial. Tehsil. Majalta, Dt: Udhampur (iii) Krishan, S/o: Braham Prakash, Vill: Khezerpur Ahir, Dist: Sonepat, Haryana (iv) Ajeet Gahlyan, S/0 Paleram, Village: Jaurasik Khalsa, Dist: Panipat, Haryana (v) Kamruddin, S/o: Sirdar, Vill: Bhagipur (Tauru)
4	High yielding strain of paddy straw mushroom (*Volvariella volvacea*)	(i) Yunus Indikar, M.V. Nagar, BEML Nagar, KGF, Kolar Dt. Karnataka (ii) Sanjit Mohanty, Pipli, Puri (iii) Dr. Natavar Rout, Johal, Bhabuneshwar
5	High yielding strain of macrocybe mushroom	(i) Raj Babadur Jandial, S/o Sh. Bodh Raj Jandial, PO; Thial. Tehsil. Majalta, Dt: Udhampur (ii) Krishan, S/o: Braham Prakash, Vill: Khezerpur Ahir, Dist: Sonepat, Haryana (iii) Ajeet Gahlyan, S/0 Paleram, Village: Jaurasik Khalsa, Dist: Panipat, Haryana (iv) Kamruddin, S/o: Sirdar, Vill: Bhagipur (Tauru)

Table 2. Performance evaluation of technologies in farmers' field conditions and recommendations

Technology	No. of experiment	Yield performance			Quality			Observation/ Recommendations
		Lower	On par	Higher	Lower	On par	Superior	
Non browning strain of white button mushroom *(Agaricus bisporus)* NBS-1	11	-	2 (18.18)	9 (81.82)	-	1 (9.09)	10 (90.91)	NBS-1 was found superior with respect to yield and quality. This variety performed very well in farmers' field and hence can be promoted among many farmers to raise their yield and income.
Non browning strain of white button mushroom *(Agaricus bisporus)* NBS-5	9	-	2 (22.22)	7 (77.78)	-	-	9 (100)	NBS-5 was found superior with respect to yield and quality. This variety performed very well in farmers field and hence can be promoted among many farmers to raise their yield and income.
Short duration cultivation technology of shiitake mushroom *(Lentinula edodes)* OE- 388S	6	-	2 (33.33)	4 (66.67)	2 (33.33)	3 (50.00)	1 (16.67)	The short duration technology of shiitake is very potent technology to promote shiitake mushroom in India. The quality improvement research in shiitake can be thought off to address the poor quality of the tested variety.
High yielding strain of *Macrocybe* mushroom *(Macrocybe* sp)	9	4 (36.36)	2 (18.18)	5 (45.45)	1 (11.11)	3 (33.33)	5 (55.55)	Though the quality was good, the results were not consistent in yield. Inconsistent yield was also due to unfavourable cropping conditions by some of the farmers. The cropping in Himachal pradesh was not successful because of low temperature prevailing in the region. Hence, the variety is recommended only in tropical regions.
High yielding strain of milky mushroom *(Calocybe indica)*	12	3 (25.00)	2 (16.67)	7 (58.33)	-	4 (33.33)	8 (66.66)	Though the quality was good, the results were not consistent in yield. Inconsistent yield was also due to unfavourable cropping conditions by some of the farmers. The cropping in Himachal Pradesh was not successful because of low temperature prevailing in the regions. Hence, the variety is recommended only in tropical regions.
High yielding strains of paddy straw mushroom (*Volvariella volvacea*)	10	-	2(20)	8(80)	-	1	9(90)	Though the results of both the strains OE-463 and OE-484 were good in terms of yield and quality based on the results of trials in three season among four places. This needs further testing to establish the reliability of the results.

the existing/ expected level of the adopter of the technology. The frequencies and percentages of the data for all three categories are mentioned in table 2.

The non browning strains were tested in different units. NBS-1 was given for On-farm trial in l l locations and NBS-5 was tested in 9 locations. The results of both the strains were very good. The yield performance of NBS-1 was higher in 81.82 % cases while in the remaining units the farmers reported its yield as on par with their existing verities. NBS-5 was found favour with 77.78 % farmers while the remaining (22.22%) reported the yield as on par with their existing varieties. None of the farmers reported the yield as lower than the existing varieties speak for the level of satisfaction among the adopters of the variety. Further, the quality of both these improved strains was highly appreciated by the farmers and entrepreneurs as 100 farmers in respect of NBS-5 and 90 % farmers reported the varieties as superior on quality. Since, the varieties were developed for the purpose of non-browning, the satisfaction of the adopters augurs well for the promotion of these two strains among the commercial mushroom growers.

The short duration cultivation technology of shiitake mushroom (*Lentinula edodes*) tried in 6 different trials and was found superior by 66.67 % respondents while 33.33 % respondents found them on par with their expectation. However, on quality aspects 50 per cent reported as on par while 33.33 per cent reported lower than expected. One trial gave superior quality. The entrepreneurs focusing on the quality of the shiitake mushroom must be given the other options of improved strains. Pileus thickness, pileus diameter and short stipe are considered as the desired traits in shiitake mushroom (Sharma et al, 2018). Hence, the future research should focus on the improvement in these quality traits of OE-388s strain of shiitake.

The two tropical mushrooms; milky and *Macrocybe* mushrooms were tested for on farm trials for their popularisation and promotion among the mushroom growers. Since the two varieties were not particularly grown by the farmers, they were convinced to grow them on commercial scale by providing the spawn of these two mushroom varieties. Among the adopters, seven out of 12 (58.33%) in milky mushroom and 5 out of 9 (45.45%) reported higher yield than the expected. Though, around 25 % adopters of milky and 36.36 % adopters of *Macrocybe* were reporting lower yield, this can be addressed as the adoption of milky mushroom and *Macrocybe* mushrooms were new to the region in some places like Himachal Pradesh and Haryana. Since milky mushroom has a tested and proven technology, this mushroom can be popularised in India as it is highly versatile with respect to its raw material suitability and suitability for growing in high humid tropical regions of the country (Kumar *et al.*, 2017; Navathe *et al.,* 2014).

The on farm trials of paddy straw mushroom (*Volvariella volvacea*)were mostly laid in Odisha and Karnataka state. OE-463 and OE-484 strains were selected for on farm trial in 10 different experiments. Off these 80 % trials gave superior yield and 90 per cent gave superior quality.

Constraints experienced by the farmers in adopting the new technologies in mushroom cultivation and suggestions to overcome them

The farmers were given critical input for testing of the technologies in their farm. The farmers were asked about the constraints and problems faced by them both at the time of testing and after the testing of the technologies. The constraints as mentioned by the farmers are listed below under each of the technology tested. Need based suggestions are given based on the constraints faced.

Suggestions and recommendations based on the on farm trial for technology refinement

- The non-browning strains selected for on farm trail have given satisfactory/-excellent results in the farmers' filed. The same can be promoted in large scale among the commercial mushroom growers in different parts of the country.
- The short duration cultivation technology of shiitake mushroom results showed good results in early fruiting while the growers rated the quality of the mushrooms as poor. The future research trials must focus on improving the fruiting quality

Fig. 1. Spawn run and case run stage of Milky mushroom and macrocybe mushroom in the OFT conducted at mushroom unit of Mr. Rajesh Kumar Antil, Murthal. Dist Sonipat, Haryana

Fig. 2. On farm trials of *Agaricus bisporus* strains (NBS-1 and NBS-5) at M/s. Kulakarni farm fresh unit, Village Tigadi, dist. Belgaum in Karnataka

Fig. 3. On farm trials of *Lentinula edodes* strains (OE 388S) at Mr. Harikishan Mushroom Unit, village Dharot, Dist. Solan, Himachal Pradesh

Fig. 4. On farm of *Lentinula edodes* strains (OE 388S) at M/s Vikas Mushroom Farm, village Shamlech, Dist. Solan, Himachal Pradesh

Fig. 5. On farm trials of paddy straw mushrooms in Village Pipli, dist Bhubaneswar, Odisha

of the selected strain. Besides, the strains with quality fruiting bodies must be tested and research interventions can be explored to shorten their fruiting cycle.

- The *Macrocybe* variety performed differently in different farmers' field. The lack of uniformity of pasteurization process and the spawn quality could be the reason for different results. Hence, the performance could not be ascribed to any one parameter. However, mixed results in one farmer's field suggests that, the package of practices for this mushroom needs further

Table 3. Constraints in mushroom cultivation technology adoption and suggestions

Sl. No	Technology	Constraints	Suggestions
1	Non browning strain of white button mushroom *(Agaricus bisporus)*	The multiplication of spawn from culture tube delayed the trial and results.	Instead of culture tubes, the supply of mother spawn will help fast implementation of technology at the farmers field.
		Mother culture was not supplied regularly	Regular supply of mother culture should be ensured through speed post
2	Short duration cultivation technology of shiitake mushrooms (*Lentinula edodes*) most time	Number of synthetic logs were less.	Minimum 150 logs will ensure proper yield
		The climate was not favourable controlled unit for proper trials	Implementation in environment
		No market for harvested products	Buy back was suggested by farmers
		Quality of the fruiting bodies was not uniform and good	Research issue and hence must be addressed through research program on breeding of shiitake mushrooms.
3	High yielding strain of	Fruiting was not uniform	Package of practices should be standardised
	Macrocybe mushroom (*Macrocybe* sp) and milky mushroom (*Calocybe indica*)	Very less fruiting	-do-
		Fruiting bodies are very large.	Proper fruiting bodies through varietal improvement
4	High yielding strain of paddy straw mushroom (*Volvariella volvacea*)	Timing of the trials were delayed	Environment controlled units also to be included in the trials

investigation to conclusively recommend among the farmers in large-scale adoption.

- The milky mushroom variety gave good fruiting bodies among majority trials and hence could be popularized among the mushroom growers in tropical climate. Some growers suggested to reduce the pileus size of the mushrooms for better marketing. This can be included in the research agenda of the ICAR DMR varietal improvement programmes.
- The high yielding strain of paddy straw mushroom gave superior results in comparison to the existing varieties in the farmer's field. The newly developed varieties may be promoted among the farmers in Odisha and regions with similar climate.

On-farm research is often used to generate new or modified technologies that are more appropriate. Moving to farmers' fields and interacting with farmers allows the researcher to have an appreciation of the farmers' conditions and problems. It also provides a great opportunity for the identification of problem areas and researchable issues that may arise following farmer's use of developed technology. This leads to a continuous process of refining, improving, and re-testing the system. With increasing demand for edible mushrooms, mushroom cultivation is getting prominence in India than ever before. This has led to increased thrust on the scientists and technologists to give need based technologies to farmers and entrepreneurs to increase their farm income. The technology generation is not end in itself. Hence, the technology must find favour with the stakeholders. Therefore, the on farm research trials of the five technologies tested was new effort to address the issues of both technology assessment and refinement and also to promote the diverse mushrooms in non-traditional areas to expand the availability of edible mushrooms to the consumers. Though most potent technologies were selected among the pool of technologies developed by ICAR-Directorate of Mushroom Research, Solan, other technologies can

be considered for their refinement and subsequently to their adoption by the mushroom growing farmers and entrepreneurs.

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