



Performance of high yielding drought tolerant varieties of maize and *in situ* moisture conservation techniques in Kandi region of Punjab, India

Vijay Kumar*, Vivek Sharma, S. C. Sharma and Sukhvinder Singh

Regional Research Station for Kandi Area (Punjab Agricultural University), Ballawal Saunkhri, Balachaur, SBS Nagar- 144521 (Punjab), INDIA

*Corresponding author. E-mail: vijaypau@pau.edu

Received: July 5, 2016; Revised received: October 26, 2016; Accepted: January 30, 2017

Abstract: In the present investigation, 87 front line demonstrations (FLDs) of maize were conducted on farmers' fields to demonstrate the impact of high yielding drought tolerant varieties (JH 3459, Parkash and PMH 1) and *in situ* moisture conservation techniques (ridge sowing, sowing across the slope, summer ploughing and earthing up) on production and economic benefits in Kandi region of Punjab state during *kharif* seasons from 2011 to 2013 under rainfed situation. The improved production technologies recorded additional yield ranging from 29.7 to 47.6 q/ha with a mean yield of 37.1 q/ha and 24.4 to 42.6 q/ha with a mean yield of 32.7 q/ha for drought tolerant varieties and *in situ* moisture conservation techniques, respectively. The per cent average increase in yield of drought tolerant varieties over local cultivars was 35.8, while 15.6 for *in situ* moisture conservation techniques. The average extension gap, technology gap and technology index were 9.8 & 4.4 q/ha, 3.7 & 6.1 q/ha and 9.1 & 16.7 per cent, respectively in drought tolerant varieties and *in situ* moisture conservation techniques. FLDs recorded higher mean net returns i.e. Rs. 36,292 and 28,234 per ha. with B:C ratio of 2.53 and 2.17 for drought tolerant varieties and *in situ* moisture conservation techniques, respectively. The FLDs conducted revealed that availability of suitable high yielding variety and lack of knowledge about improved production technologies is the main bottleneck in maize production, enhancement of yield and knowledge of the farmers. Hence, the productivity of maize can be increased by adoption of the recommended management practices and the study resulted in convincing the farming community about potentialities of the recommended production technologies in yield enhancement.

Keywords: FLDs, Improved Technologies, *In situ* Moisture Conservation, Maize

INTRODUCTION

Maize (*Zea mays* L.) is the most important world's leading cereal crop having wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. It is cultivated in about 160 countries having wider diversity of soil, climate, biodiversity and management practices. During 2013, globally it was cultivated on an area of 185.1 m ha with production of 1018.1 m tonnes (FAO, 2013). In India, maize is the third most important food crops after rice and wheat and is being cultivated on 9.5 m ha with 80 per cent area during *kharif* season. The current maize production in India is 23.3 mt with an average productivity of 24.5 q/ha which is less than half of world productivity (54.9 q/ha). In Punjab, it is grown on 0.13 m ha area with production of 0.48 m ton and productivity of 36.8 q/ha (Anonymous, 2013). The sub-mountainous region in the North-Eastern part of Punjab in the form of a 10 to 20 km wide strip immediately next to Shiwalik hills is known as '*Kandi*'. The area of *kandi* region is approx. 3.93 lakh hectares which comprises approximately 7.8 per cent

of total geographical area of the State. This zone is located between 30⁰44' and 32⁰32' N latitude and 75⁰52' and 76⁰43' E longitude at an elevation of 300-500 m above mean sea level. The productivity of maize is lower as compared to average state productivity in this region due to cultivation of the crop under rainfed conditions as well as poor knowledge about drought tolerant varieties & production. The productivity of maize per unit area could be increased by adopting recommended scientific and sustainable management production practices using suitable high yielding varieties (Dhaka *et al.*, 2010 and Ranawat *et al.*, 2011). Frontline demonstration is the new concept of field demonstration evolved by the Indian Council of Agriculture Research (ICAR) with main objective to demonstrate newly released crops, production and protection technologies and its management practices in the farmers' fields under different farming situations & different agro-climatic regions of the country. While demonstrating the technologies in the farmer's fields, the main objective is to study the factors contributing higher crop production, field constraints of production and thereby generate production data and feedback

information. Keeping all above into considerations, frontline demonstrations on maize (on farmer's fields) were conducted to demonstrate the production potential and economic benefits of recently developed varieties (drought tolerant & high yielding) and *in situ* moisture conservation techniques to the farmers and convincing the farmers to adopt the improved production technologies of maize.

MATERIALS AND METHODS

A total of eighty seven frontline demonstrations (FLDs) were conducted during *Kharif* season from 2011- 2013 on farmers' fields under rainfed conditions in villages such as Naude Majra, Rajgiri, Jhandian, Jatawar, Dhamana (Distt. Rupnagar), Achalpur and Nainwan (Distt. Hoshiarpur) of Punjab to demonstrate the effect of high yielding drought tolerant maize hybrids and *in situ* moisture conservation techniques on the productivity of maize. The soils of the farmer fields were coarse to medium in texture, neutral to slightly saline in reaction, low in organic carbon and available nitrogen and medium to high in available phosphorus & potassium. Each demonstration was conducted on an area of 0.1 to 0.2 ha and adjacent plot to the demonstration plot was kept as farmers practices.

To popularize the improved maize production practices, constraints in maize production were identified through participatory approach. Preferential ranking technique was utilized to identify the constraints faced by the respondent farmers in maize production. Farmers were also asked to rank the constraints they perceive as limiting factor for maize cultivation in order of preference. Based on top rank farmers problems identified, front line demonstrations were planned and conducted at the farmer's fields. The improved technologies selected for FLDs were improved high yielding drought tolerant varieties and different *in situ* moisture conservation techniques (Table 1). The other management practices like seed treatment, maintenance of optimum plant stand, recommended fertilizers dose and plant protection etc. were applied for improved as well as farmer practice and they only differed for either variety or *in situ* moisture conservation technique as per FLD. The demonstrations were sown in last week of June to second week of July during the three years with the seed rate of 20 kg/ha and spacing of 0.45 m x 0.25 m. All the crop management practices as per the package of practices for *Kharif* crops by Punjab Agricultural University, Ludhiana were followed for raising the crop. The yield attributing traits like number of cobs/100 plants, cob length (cm) and cob girth (cm) were taken from average of ten cobs and shelling percentage were recorded and compared with local variety in case of FLDs on drought tolerant varieties, while production and economic data was recorded and analysed for all FLDs and local practices.

The average of the individual improved/ local practice for the three years has been taken for interpretation of the results.

Shelling % = $\frac{\text{Grain weight after shelling}}{\text{dry weight of the cobs}} \times 100$

The extension gap, technology gap and technology index were calculated using the formula as suggested by Samui *et al.* (2000).

Extension gap (q/ha) = Demonstration yield (q/ha) – Yield of improved technology (q/ha).

Technology gap (q/ha) = Potential yield (q/ha) – Demonstration yield (q/ha).

Technology index (%) = $\frac{\{\text{Potential yield} - \text{Demonstration yield}\}}{\text{Potential yield}} \times 100$

Knowledge level of the farmers about improved production practices of maize before frontline demonstration implementation and after implementation was measured and compared by applying paired t-test at 5 per cent level of significance.

RESULTS AND DISCUSSION

Constraints in maize production: Problems faced by the farmer's in maize cultivation were documented during the study. Preferential ranking technique was utilized to identify the constraints faced by the respondent farmers in maize production and rankings given by the farmers to different constraints are given in Table 2. A perusal of table indicates that availability of suitable high yielding variety (HYV) seed (82%) was given the top most rank followed by low technical knowledge (74%), wild animal damage (70%), and uncertainty of monsoon rains/drought (68%) were the major constraints to maize production. Other constraints such as stem borer infestation, weed infestation, water lodging and post harvest management were also found to reduce maize production. Dhruw *et al.* (2012), Sreelakshmi *et al.* (2012) and Meena *et al.* (2014), Kumar *et al.* (2015) and Sharma *et al.* (2016) have also reported similar problems in maize and other crops and the results also indicated similar constraints in maize production.

Increase in knowledge: The knowledge level of the farmers on various aspects of improved production technologies in maize increased by 26.50 after implementation of frontline demonstrations (Table 3). As the computed value of 't-test' (9.32) was statistically significant at 5 % probability level. In other words there was significant increase in knowledge level of the farmers due to frontline demonstration. The results of the present study are at par with the reports of Singh and Sharma (2004) on mustard crop, Malik *et al.* (2005) and Dhaka *et al.* (2010) on maize crop and Sharma *et al.* (2016) on wheat crop who also reported increase in knowledge through FLDs. This shows positive impact of frontline demonstration on knowledge of the farmers that have resulted in higher adoption of improved farm practices.

Table 1. Particulars showing the details of maize growing under FLD and farmer practices.

S. No.	Technology	Farmers Practice	Improved practices
1	Variety	Local/unknown variety from local market	Drought tolerant varieties JH 3459, Parkash, PMH 1
2	Spacing	Broadcasting of seed	Line sowing with spacing of 45 cm between rows and 25 cm between plants in the row.
3	Seed rate	25-30 kg/ha	20 kg/ha
4	Summer ploughing	Most of the farmers don't open the fields in the month of June.	Fields were ploughed in the month of June before onset of monsoon rains. It makes the field surface rough and cloddy, exposes more surface area which helps in increasing rainwater interception and more opportune time to infiltrate, thereby improving soil moisture content and reducing runoff & soil erosion. It helps to kill weeds, hibernating insects and disease-causing organisms by exposure to summer heat.
5	Ridge sowing	Sowing on flat bed with broadcasting method	Sowing on ridges prepared with ridge maker.
6	Earthing up	Most of the farmers do not perform this operation due to either non availability of labour or lack of knowledge	Earthing up is done in the after about one month of sowing at knee height stage as it gives support to plant as well as save from water logging.
7	Other crop management & protection practices	Farmers are cultivating these crop without adoption of any improved technology	All the crop management practices as per the package of practices for <i>Kharif</i> crops by Punjab Agricultural University, Ludhiana were followed for raising the crop.

Table 2. Ranks given by farmers for different constraints (n=100).

S. No.	Constraints	Percentage	Ranks
1	Availability of suitable HYV seed	82	I
2	Stem borer infestation	52	V
3	Low soil fertility	30	VIII
4	Low technical knowledge	74	II
5	Damage by wild animals	70	III
6	Uncertainty of Monsoon/drought	68	IV
7	Weed infestation	35	VI
8	Water lodging	33	VII
9	Post harvest management	27	IX

Table 3. Comparison between knowledge levels of the respondent farmers about improved management practices of maize (n=50).

	Mean score		Calculated 't' value
	Before FLD	After FLD	
	42.50	69.0	26.50
			9.32*

Significant at 5% probability level

Performance of frontline demonstrations

Yield attributing traits: The average number of cobs per 100 plants in drought tolerant varieties was 121 in comparison to 98 in case of local cultivars and it ranged from 118 to 124 in drought tolerant varieties

(Table 4), while it ranged from 95 to 102 in local cultivars with average increase of 22.8 per cent over local cultivars. The cob length and cob girth was also more in case of drought tolerant varieties and it ranged from 15.8 to 16.7 cm and 11.8 to 13.5 cm with an average of

Table 4. Yield attributing traits of high yielding drought tolerant maize hybrids.

Variety	Yield attributing characters											
	Number of cobs			Shelling %			Cob length (cm)			Cob girth (cm)		
	IT	FP	% increase	IT	FP	% increase	IT	FP	% increase	IT	FP	% increase
JH3459	120	95	26.3	82.5	70.8	16.5	16.1	14.4	11.8	12.2	10.4	17.3
Parkash	118	102	15.7	84.8	72.6	16.8	15.8	13.9	13.7	11.8	10.1	16.8
PMH 1	124	98	26.5	81.4	68.4	19.0	16.7	14.2	17.6	13.5	10.2	32.4
Average	121	98	22.8	82.9	70.6	17.4	16.2	14.2	14.4	12.5	10.2	22.2

IT = Improved Technology, FP = Farmers' Practice

16.2 and 12.5 cm, respectively. The average increase in cob length and cob girth was 14.4 and 22.2 per cent, respectively over the local cultivar. The shelling percentage ranged from 81.4 to 84.8 with an average of 82.9 in comparison to average value of 70.6 in local cultivars. The per cent increase in shelling percentage over local cultivars was 17.4. These results showed significant increase in the yield attributing traits in case of drought tolerant varieties. The yield of the farmers' field is on the lower side because they are still using local / unknown cultivars due to non-availability of the quality maize seed or due to higher price of the hybrid seed available in the market.

Yield: It was observed that the productivity of maize in the FLDs ranged between 29.7 to 47.6 q/ha and 24.4 to 42.6 q/ha with a mean yield 37.1 and 32.7 q/ha for drought tolerant varieties and *in situ* moisture conservation techniques, respectively (Table 5). The productivity under drought tolerant varieties varied from 30.0 to 44.4, 29.7 to 37.4 and 34.7 to 47.6 q/ha for the varieties JH 3459, Parkash and PMH 1, respectively as against the average yield of 27.4 q/ha for local cultivar even under improved management practices. However, productivity under different *in situ* moisture conservation techniques varied from 31.2 to 34.3, 24.4 to 42.1, 30.0 to 36.0 and 26.7 to 42.6 q/ha for the ridge sowing, summer ploughing, sowing across the slope and earthing up, respectively against the average yield range from 27.1 to 29.8 with a mean of 28.3 q/ha of farmer practices. The additional yield of different varieties over local cultivar ranged 5.2 to 13.5 q/ha with a mean of 9.8 q/ha in comparison to local varieties, while it ranged between 2.9 to 6.0 q/ha with a mean of 4.4 q/ha in comparison to farmer's practices for *in situ* moisture conservation techniques. The per cent increase in yield ranged from 18.8 to 49.4 and 10.2 to 22.1 with an average of 35.8 and 15.6 per cent, respectively for drought tolerant varieties and *in situ* moisture conservation techniques over farmer practices.

The variation in the productivity was caused by delay in sowing in some of the farmer's fields due to delayed onset of monsoon, prolonged dry spell during the growth period and variation in soil fertility in the farmer fields. Similar, enhancement in productivity of different crops through front line demonstration has been documented by Tiwari *et al.* (2003), Sreelakshmi *et al.* (2012), Meena *et al.* (2014), Kumar *et al.* (2014) and Sharma *et al.* (2016) and the FLDs conducted in the present investigation also resulted in enhanced productivity which is in line with the results of these workers. The results indicated that performance of improved varieties was better than the local cultivars and farmers were motivated by HYVs and improved technologies demonstrated in the FLDs which will result in adoption of these improved technologies.

Extension gap: Extension gap is the difference in the

Table 5. Seed yield of Maize as affected by high yielding improved technologies in farmer fields.

Improved Technology	Demonstration (No.)	Yield (q/ha)		Farmer practise (FP)	Potential Yield (q/ha)	Additional yield over farmer practice	% increase in yield over farmer practice	Ext. Gap (q/ha.)	Tech. Gap (q/ha.)	Tech. index (%)
		Maximum	Minimum							
<i>Drought tolerant varieties</i>										
JH3459	15	44.4	30.0	37.7	27.0	40.0	10.7	39.3	10.7	5.7
Parkash	15	37.4	29.7	33.2	28.0	37.5	5.2	18.8	5.2	11.5
PMH 1	15	47.6	34.7	40.5	27.0	45.0	13.5	49.4	13.5	10.0
Average	15	43.1	31.5	37.1	27.4	40.8	9.8	35.8	9.8	9.1
<i>In situ moisture conservation techniques</i>										
Ridge sowing	6	34.3	31.2	33.1	27.1	38.8	6.0	22.1	6.0	15.6
Summer ploughing	12	42.1	24.4	31.3	27.5	38.8	3.8	13.7	3.8	20.5
Sowing across slope	12	36.0	30.0	31.7	28.8	38.8	2.9	10.2	2.9	19.5
Earthing up	12	42.6	26.7	34.8	29.8	38.8	4.9	16.6	4.9	11.0
Average		38.8	28.1	32.7	28.3	38.8	4.4	15.6	4.4	16.7

*Average of the yield of JH 3459 and Prakash was taken as potential yield (these varieties were used in FLDs)

Table 6. Cost of cultivation (Rs/ha), net return (Rs/ha) and benefit: cost-ratio of Maize as affected by improved and farmer practices.

Technology	Cost of cultivation (Rs/ha)		Net returns (Rs/ha)		Additional cost of cultivation (Rs./ha)	Additional net returns (Rs./ha)	B:C Ratio	
	IT	FP	IT	FP			IT	FP
Drought tolerant varieties								
JH3459	24121	21998	36722	24474	2124	12248	2.56	2.17
Parkash	23754	21998	30600	24474	1757	6126	2.42	2.17
PMH 1	26259	21998	41554	24474	4261	17079	2.61	2.17
Average	24711	21998	36292	24474	2714	11818	2.53	2.17
<i>In situ</i> moisture conservation techniques								
Ridge sowing	25033	24024	28994	20103	1008	8891	2.16	1.85
Summer ploughing	23396	23086	24933	20000	310	4932	2.11	1.89
Sowing across slope	23542	23348	25008	23191	194	1817	2.14	1.98
Earthing up	26810	25210	34001	28701	1600	5300	2.26	2.08
Average	24695	23917	28234	22999	778	5235	2.17	1.95

yield of the demonstration and farmers practices. The value of extension gap (Table 5) varied from 5.2 to 13.5 q/ha for drought tolerant varieties, 2.9 q/ha to 6.0 q/ha for *in situ* moisture conservation techniques with an average value of 9.8 q/ha and 4.4q/ha, respectively which may be due to non-availability of quality seed and inputs and lack of knowledge among farmers. Hence, to exploit the potential of improved production and protection technologies efforts through FLDs ought to be increased awareness among the farmers. It shows that the different extension agencies have to make hard efforts to technologically backing of the extension agency for the speedy transfer of the recommended technology to the farmers' fields. Further, the above extension gap emphasized the need to educate the farmers through various means for adoption of improved agricultural production technologies to reduce this extension gap. Increased use of latest production technologies with high yielding varieties will subsequently change the trends of extension gap which in turn would lead to higher productivity, farmers' income and prosperity.

Technology gap: The technology gap shows the gap in the demonstration yield over potential yield and it ranged between 2.3 q/ha to 4.5 q/ha with average of 3.7 q/ha for drought tolerant varieties (Table 5), while for *in situ* moisture conservation techniques it ranged between 4.0 q/ha to 7.5 q/ha with average of 6.1 q/ha. The observed technology gap may be due dissimilarity in the soil fertility status, weather condition and other

management practices (Tiwari *et al.*, 2014 and Sharma *et al.*, 2016). Hence variety-wise location specific recommendation with full package of practices and other pre-requisite appears to be necessary to minimize the technology gap for yield level under different situations. Such steps would boost up the production and bring more prosperity to the farming community.

Technology index: Technology index varied from 5.7 (JH 3459) to 11.5 (Parkash) per cent with average of 9.1 per cent for drought tolerant varieties (Table 5), whereas it varied from 11.0 (earthing up) to 20.5 (summer ploughing) per cent with average of 16.7 per cent for *in situ* moisture conservation techniques and showed the feasibility of the varieties as well as *in situ* moisture conservation techniques at the farmer's field. The lower the value of technology index more is the feasibility of the improved technology in the farmer's field as this indicated that technology is suitable for the particular region. The variation in yield from location to location can be accounted for varying climatic condition, prevailing microclimatic and variation in agricultural practices followed. The findings of the present study about extension gap, technology gap and technology index (%) are in line with the findings of Dhaka *et al.* (2010), Meena *et al.* (2014) and Sharma *et al.* (2016).

Economics: The economic analysis of improved technologies over traditional farmer's practices was calculated depending on the prevailing market prices of inputs and outputs (Table 6). It was found that cost

of production of maize under improved technologies varied from Rs. 24,121 to Rs. 26,259 and 23,396 to 26,810 with average of 24,711 and 24,695 for drought tolerant varieties and *in situ* moisture conservation techniques, respectively in comparison to average cost of production of Rs. 21,998 & 23,917 for local practices. The additional cost incurred in the improved technologies was mainly due to more costs involved in the cost of improved seed and cultural practices involved in case of *in situ* moisture conservation techniques. FLDs recorded higher mean net returns i.e. Rs. 36,292 and 28,234 per ha with higher B:C ratio of 2.53 and 2.17 for drought tolerant varieties and *in situ* moisture conservation techniques, respectively. These results are in line with the findings of Hiremath and Nagaraju (2009) and Sreelakshmi *et al.* (2012) and Kumar *et al.* (2015) who also reported higher net returns and B:C ratio in the FLDs compared to farmers' practices. Further, the average additional cost of Rs.2714 and 778 per ha has yielded additional net returns of Rs. 11,818 and 5,235 per ha in FLDs on drought tolerant varieties and *in situ* moisture conservation techniques, respectively suggesting higher profitability and economic viability of the FLDs which are in line with the results of Hiremath and Nagaraju (2009). The results from the present study clearly brought out the potential of improved production technologies in enhancing maize production and economic gains in rainfed farming situations.

Conclusion

FLDs conducted at the farmers' fields revealed that the adoption of improved production technologies significantly increased the yield as well as yield attributing traits of the crop and also the net returns. It can be observed that increased yield was due to adoption of high yielding varieties, *in situ* moisture conservation techniques and proven production technologies. So, there is need to disseminate the improved production technologies among the farmers with effective extension methods like training and demonstrations. The farmers should be encouraged to adopt the recommended package of practices for the crop for higher returns. The study reported lack of suitable high yielding drought tolerant maize varieties as major constraint by the beneficiaries and is ranked first followed by low technical knowledge, damage by wild and stray animals and uncertainty of monsoon/drought. Hence, farmers should be encouraged to adopt the recommended package of practices for the crop for higher returns.

ACKNOWLEDGEMENTS

We sincerely thank all the farmers of different villages on whose fields' frontline demonstration were conducted. The financial assistance and technical

support provided by All India Coordinated Research Project for Dryland Agriculture, National Initiative for Climate Resilient Agriculture (NICRA) and Directorate of Research, Punjab Agricultural University, Ludhiana is duly acknowledged. The views expressed in this paper are those of individual scientists and do not necessarily reflect the views of the donor or the authors' institution.

REFERENCES

- Anonymous (2013). Statistical Abstracts of Punjab. <http://www.esopb.gov.in/static/PDF/Statistical-Abstract-2013.pdf>
- Dhaka, B.L., Meena, B.S. and Suwalka, R.L. (2010). Popularization of improved maize production technology through frontline demonstrations in south-eastern Rajasthan. *J. Agril. Sci.* 1(1):39-42.
- Dhruw, K.S., Sengar, R.S. and Yadav, K.N. (2012). Level of knowledge and adoption about recommended maize production technology. *Agril. Update* 7(3&4):311-315.
- FAO. (2013). FAO Agricultural Production Statistics, <http://faostat3.fao.org/> as accessed on 17 April 2015.
- Hiremath, S.M. and Nagaraju, M.V. (2009). Evaluation of front line demonstration trials on onion in Haveri district of Karnataka. *Karnataka J. Agril. Sci.* 22 (5):1092-1093
- Kumar, V., Sharma, V. and Sharma, S.C. (2014). Impact of improved technologies on productivity enhancement of sesame (*Sesamum indicum* L.). *Indian J. Dryland Agril. Res. & Dev.* 29(2): 41-44
- Kumar, V., Sharma, V. and Sharma, S.C., Singh. S. and Sharma, R.K. (2015). Productivity enhancement in sesame (*Sesamum indicum* L.) as influenced by different improved production technologies. *J. Oilseed Res.* 32 (1): 87-90
- Malik, R.S., Sherawat, R.S., Sube, S., Loveraj, S. (2005). Relationship of farmers' trait with knowledge of rapeseed-mustard production technology. *J. Oilseeds Res.* 22(1):159-161
- Meena B. L., Meena, R. P., Meena, R. R. and Bhim Singh (2014). Popularization of improved maize (*Zea mays* L.) production technology through frontline demonstrations in semi arid zone IVA of Rajasthan. *J. Appl. Nat. Sci.* 6 (2): 763-769
- Ranawat Y., Ram, H., Sisodiya, S.S. and Punjabi, N.K. (2011). Adoption of improved maize cultivation practices by trained and untrained farmers of KVK, Udaipur. *Rajasthan J. Ext. Edu.* 19:144-147
- Samui, S.K., Maitra, S., Roy, D.K., Mondal, A.K. and Saha, D. (2000). Evaluation of front line demonstration on groundnut (*Arachis hypogea* L.) in Sundarbans. *J. Indian Soc. Coastal Agril. Res.* 18 (2):180-183
- Sharma, V., Kumar, V., Sharma, S.C. and Singh. S. (2016). Productivity enhancement and popularization of improved production technologies in wheat through frontline demonstrations. *J. Appl. Nat. Sci.* 8 (1): 423 - 428
- Singh, N. and Sharma, F.L. (2004). Impact of front line demonstration on gain in knowledge about mustard production technology among farmers. 2nd National Extension Education Congress, May 22-24, 2004. Society of Extension Education, Agra & MPUAT, Udaipur: 56.

- Sreelakshmi, C.H., Sameer Kumar, C.V. and Shivani, D. (2012). Productivity enhancement of pigeon pea (*Cajanus cajan* L.) through improved production technology. *Madras Agril. J.* 99 (4-6): 248-250
- Tiwari, B. K., Aashutosh Sharma, Sahare, K. V., Tripathi, P. N. and Singh, R. R. (2014). Yield gap analysis of wheat (*Triticum aestivum*) through front line demonstration under limited irrigation conditions. *Plant Archives* 14 (1): 495-498
- Tiwari, R.B., Singh, V., and Parihar, P. (2003). Role of front line demonstration in transfer of gram production technology. *Maharashtra J. Ext. Edu.* 22 (1): 19