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Site specific varietal performance on yields and economics of lentil (*Lens culinaris* Medik.)

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Abstract
Lentil is one of the most important pulse crops of Madhya Pradesh which is used as a primary source of protein for human beings as well as nitrogen for many cropping systems. Lentil crop leaves is a reasonably good amount of atmospheric nitrogen in readily available form to the succeeding crop. India ranked first in the area and second in the production with 43 percent and 37 percent of world area and production respectively. It was observed that low productivity of lentil in Sagar district was attributed due to unavailability of quality seed of wilt resistant varieties. Wilt is a major biotic stress of low production of lentil. Due to this reason farmers prefer to grow wheat in Rabi season in place of pulses. Keeping this in view the On-Farm trials were conducted in the year 2015-16 and 2016-17 during Rabi season in village Sazi, Baroda, Baddaua, Oriya and Hasrai in Sagar district of M.P. It was observed that high yielding wilt resistant varieties JL 3 and IPL 81 gave more yield as compared to farmer's practices. The highest grain yield was recorded in the variety IPL 81 (12.59 q/ha and 8.59 q/ha) followed by JL 3 (10.69 & 8.37 q/ha) in both the year. Yield increase from 28.97% to 32.36% (JL 3) and 21.75% to 43.39% (IPL 81) over farmers practice. The economic performance of the trials revealed that high yielding wilt resistant varieties, IPL-81 and JL-3 gave high net returns i.e. Rs 40878 & Rs 32898/ha in the year 2016-17 respectively, while in the year 2015-16, IPL-81 and JL-3 gave Rs 13770 & Rs 13110/ha respectively. The cost benefit ratio was also high with the use of variety IPL-81 i.e. 4.81 and 2.15 in the year 2016-17 & 2015-16, respectively. From the result of the trial, it can be concluded that the cultivation of high yielding wilt resistant varieties of lentil with improved technologies has been found more productive. Replacement of local/old varieties with new varieties would increase the production and net income. Farmer's reaction about use of wilt resistant variety were highly appreciable and most effective to manage wilt disease.

Keywords: Lentil, on-farm trial, varietal performance

Introduction
Pulses are important commodity group of food crops that can play a vital role to address national food and nutritional security and tackle environmental challenges. Pulses share to total food grain basket is around 9-10 per cent and critical and inexpensive source of plant-based proteins, vitamins and minerals. Pulses are a smart food as these are critical for food basket (dal-roti, dal-chawal), rich source of protein i.e. 20-25 per cent which is double the protein content of wheat and thrice that of rice and help address obesity, diabetes malnutrition etc.Pulses have a wide range of adaptability to latitudes, longitudes and climatic variables. In the production process, pulses improve soil fertility through biological nitrogen fixation, requires less water than cereals, and their rotation with cereals help in controlling diseases and pests. India is the largest producer in the world, with 26 per cent share in the global production by producing 25.23 million tons of pulses from an area of 29.99 million hectares. The average productivity of country is about 841 kg/ha against the average global productivity of 1023 kg/ha (Agricultural Statistics at a Glance, 2018) [1]. The important pulse crops are Chickpea (45.53 per cent), Pigeon pea (17.06 per cent), Urdbean (13.40 per cent), Mungbean (7.76 per cent), Lentil (5 per cent) and Field pea (5 per cent). The major pulse producing states are Madhya Pradesh (33 per cent), Maharashtra (13 per cent), Rajasthan (12 per cent), Uttar Pradesh (9 per cent), Karnataka (8 per cent), Andhra Pradesh (5 per cent), Gujrat (4 per cent), Jharkhand (3 per cent), Tamil Nadu, (2 per cent), Telangana (2 per cent) and which together for about 91 per cent of the total production (Agricultural Statistics at a Glance, 2018).In Madhya Pradesh, the total area under pulses is around 7.48 million hectares with a production of 8.11million tons. The average productivity of pulses in the states is around 1084 kg/ha (Agricultural Statistics at a Glance, 2018) [1].
Lentil (*Lens culinaris* Moench) is one of the important and most nutritious Rabi pulses. It is a bushy annual plant of the legume family, grown for its lens-shaped seeds. It is rich in calcium (560 ppm), iron, and niacin. The crop has the potential to cover the risk of rainfed farming.

It is also used as a cover crop to check the soil erosion. The plants are ploughed back into the soil as green manure. It is one of the most important Rabi pulse crops of India next to chickpea. Madhya Pradesh is the largest producer contributing about 42.26 per cent of India lentil production. Madhya Pradesh, Uttar Pradesh, West Bengal, Bihar, Jharkhand, Rajasthan, and Assam are the major lentil producing states. In India, lentil grown in an area of 1.55 million hectares and producing 1.61 million tonnes production with 1034 kg/ha productivity. Madhya Pradesh covering an area of 0.60 million hectares with production and productivity of 0.68 million tonnes and 1139 kg/ha respectively during 2017-18 (Agricultural Statistics at a Glance, 2018) [1]. It is also cultivated in sizable area of 0.46 lakh hectares, production of 0.56 lakh tonnes and productivity of 1205 kg/ha during 2016-17 in Sagar district of Madhya Pradesh (Tiwari and Shivhare, 2018) [8]. The low productivity can be attributed to several factors i.e. Unavailability of wilt resistant variety, sowing time, adoption of appropriate plant protection measures, inadequate plant stand, inadequate and imbalance use of nutrients. Wilt is the major cause of low production of lentil. Keeping this in view, Krishi Vigyan Kendra, Sagar, Madhya Pradesh conducted on-farm trial (OFT) on lentil crops to assess the varietal performance with improved package of practices on farmers' fields for enhancing production and productivity of lentil.

Methodology

Technological differences between recommended production package and practices of lentil and farmers practices were studied based on survey and group discussion with farmers interactive group (FIG) of lentil growers in selected cluster villages of district Sagar of Vindhya Plateau agro-climatic zone of Madhya Pradesh. In order to assess the effect of wilt resistant varieties of lentil, on farm trial was carried out during Rabi 2015-16 and 2016-17 at farmers field in five villages. Three treatments such as farmers practice (use of old variety with mixed seed) was carried out and designated as T_1, and under improved package and practices, wilt resistant varietyJL-3 was sown as T_2 and IPL 81 were laid out as T_3in plot size of 1000m^2 for each treatment. The soil of the field was medium black soil. Seed treatment was done with fungicide thiram @ 2.5gm/kg of seed, PSB, *Rhizobium* and *Trichoderma* @ 10gm/kg seed. The spacing was 25x10 cm (RXP) with seed rate @ 45kg/ha. The fertilizers were given as per improved practices as basal dose @ 100 kg/ha DAP. Pendimethalin 30% EC @ 3.3 lit./ha + one hand weeding at 60 days after sowing were applied. The crops were harvested at perfect maturity stage with suitable method. Need based irrigation and plant protection measures were fallowed. Observation was recorded for pods/plant and grain yield q/ha. The economics of assessed technology and the prevailing practices were studied taking into consideration the cost of cultivation, gross return, net returns and B:C ratio. The superiority of improved practices (IP) was calculated mainly in terms of increase in yield and net return from improved practices over farmers practices (FP).

Result and Discussion

The gap between recommended and existing practices of lentil in Sagar district of Madhya Pradesh is presented in table 1. Full gap was observed in case of use of suitable lentil cultivars and seed rate and partial gap was in seed treatment, use of recommended dose of fertilizers, weed management and plant protection measures, which definitely was the reason of not achieving potential yield. Farmers were not aware about improved production package and practices. Farmers' are used old-age, local small seeded lentil variety in their cultivation practices instead of high yielding resistant cultivars. Very few farmers were able to arrange seed of high yielding varieties. Availability of quality seed in time and lack of awareness were the main reasons of low productivity of lentil. Farmers applied higher seed rate than the recommended and they were using injudicious use of pesticides for seed treatment to control diseases and pests. The farmers were much concerned about importance of sowing technique and time of sowing. The results are similar with the findings of Ahmad *et al.* 2012 [2], Singh *et al.* 2018 [6] and Singh *et al.* 2019 [7].

A comparison of on farm trials based on recommended package and practices were presented in table 2. It was observed that high yielding wilt resistant varieties of lentil gave more yield than farmer's practices. The highest grain yield was recorded with the use of wilt resistant variety IPL 81 (8.59 q/ha and 12.59 q/ha) followed by variety JL 3 (8.37 q/ha and 10.69 q/ha) during the year 2015-16 and 2016-17 respectively. Yield increase up to 21.75 to 43.39 percent as compare to farmer's practices. The results are similar with the findings of Hasim Reja, *et al.* (2017) [4] and Biswas *et al.* (2018) [3].

The profitability results obtained during two years are presented in table 3. The result revealed that high yielding wilt resistant varieties gave higher net returns of Rs. 13770/ha. and Rs. 40870/ha (IPL 81) followed by Rs. 13110/ha and Rs.32898/ha (JL3) for both the year respectively as compare to farmers practices. The cost benefit ratio was maximum in variety IPL 81 (2.15 & 4.08) in both the year followed by variety JL 3 (2.09 & 4.08). Finally result revealed that higher yield was obtained in each year in lentil variety and higher cost benefit ratio supported that with the use of wilt resistant variety is far better than Farmers old and mixed seed. To enhance sustainable production potential and diversified the crop as well as enhance pulse production. Farmer's reaction about use of wilt resistant varieties were highly appreciable and more effectiveness to manage the wilt disease and higher incremental benefit cost ratio. The present results are in confirmation with Ahmad *et al.* 2012 [2] and Kumar *et al.* 2017 [5].

Table 1: Differences between technological intervention and farmers practices under OFT on lentil

SN	Particulars	Technological intervention	Existing Practices	Gap
1.	Variety	JL-3, IPL 81	Local (small seeded)	Full gap
2.	Land preparation	One cultivator ploughing and 3 ploughing	One cultivator ploughing and 2 ploughing	Nil
3.	Seed rate (Kg/ha)	45	Higher seed rate	Partial gap
4.	Sowing method	25x10cm(R x P)	Line sowing	Nil
5.	Seed treatment	Thiram @ 2.5 g/kg seed, *Trichoderma* powder and *Rhizobium* culture @ 10 g/kg seed	No seed treatment	Full gap
6.	Fertilizer dose (Kg/ha)	18 N and 46 P_2O^5	Use of Imbalance fertilizers	Partial gap
7.	Weed management	Pendimethalin	Improper chemical weed management	Partial gap

		30% EC @ 3.3 lit./ha + one hand weeding at 60 days after sowing		
8.	Irrigation	If needed, One light irrigation at maximum branching/pre flowering	Untimely irrigation	Partial gap
9.	Plant protection	Need based plant protection measure Imidacloprid 17.8% SL @ 250 ml/ha	Improper management	Partial gap

Table 2: Year wise physical progress of the assessed lentil varieties

Treatments	Pods/plant(No.)		Grain yield(q/ha)		Mean	Yield increase over FP (%)	
	2015-16	2016-17	2015-16	2016-17		2015-16	2016-17
T_1 (FP)	60	46.1	6.49	8.78	7.64	-	-
T_2-JL 3	85.7	54.9	8.37	10.69	9.53	28.97	21.75
T_3-IPL 81	87	63.8	8.59	12.59	10.59	32.36	43.39

Table 3: Effect of lentil varieties on economical attribute

Year	Treatment	Cost of cultivation(Rs.)	Gross Returns(Rs.)	Net Returns(Rs.)	B:C ratio
2015-16	T_1 (FP)	9500.00	19470.00	9970.00	2.05
	T_2-JL 3	12000.00	25110.00	13110.00	2.09
	T_3-IPL 81	12000.00	257770.00	13770.00	2.15
2016-17	T_1 (FP)	9500.00	36876.00	27376.00	3.88
	T_2-JL 3	11000.00	44898.00	32898.00	4.08
	T_3-IPL 81	11000.00	52878.00	40878.00	4.81

Conclusion

There was a technological gap between improved management package and farmers practice in lentil crop. The adoption of recommended improved crop production technology and plant protection measure was poor. Full gap was received in use of suitable lentil cultivars and seed rate and partial gap was in seed treatment, use of recommended dose of fertilizers, weed management and plant protection measures, which definitely was the reason of not achieving potential yield. Yield enhancement were recorded up to 21.75 to 43.39 percent as compare to farmers practices. This also improved the relationship between farmers and KVK scientists and built confidence between them. Based on farmer's feedback, it was observed that the use of improved production and protection technology of lentil was highly acceptable, easily compatible in existing production and cropping systems.

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