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Maize Production under Abiotic Stress Condition: An Empirical Analysis

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ABSTRACT

Maize in Samastipur is grown during kharif season at 22% of cropped area, during Rabi season on less than 12% area, as sole crop and 26% as intercrop. However, summer maize occupies only 6 percent of the cropped area in the region. The district frequently faces problems of abiotic stress due to flash floods and drought conditions. Keeping in view frequent abiotic stress faced by the farmers, the present study was planned and data solicited from 120 farmers under different categories from six villages selected from Patori and Vidhyapatinagar blocks of, Samastipur district, Bihar. The study finds that farmers save Open Pollinated Variety (OPV) maize seeds for future use but buy hybrid seeds through input dealers. The estimated total cost of production per hectare in case of hybrid varieties during, *Kharif, Rabi* and *Summer* seasons worked out to be Rs 8689.46, Rs.20918.43 and Rs.16126.63 respectively. However, in case of OPVs it was lower at Rs 9956.57 in *Kharif*, Rs 6797.44 in *Rabi* and Rs 11907.87 in summer season. Use of human labour and chemical fertiliser had higher share in the cost structure across the seasons and varieties. So far as the disposal of produce was concerned, 64 to 72 % was sold at price ranging from Rs 789 to Rs 854 per quintal. The study found that adoption of OPVs was a strategy by farmers to counter the abiotic stress conditions, as it was more tolerant. The hybrid variety is mostly cultivated for selling in the market and not for home consumption. The study suggests that suitable varieties and technologies should be developed for abiotic stress situations so that area and productivity could increase in future. The increase in productivity will have a positive impact on food and nutrition security. Improvement in marketing support to the crop was essential to ensure so that income and remuneration will increase and finally uplift the socio- economic conditions in the study area.

Keywords: Maize production, Abiotic stress, Economics, OPV

INTRODUCTION

Maize also known as corn is an important cereal in many developed and developing countries of the world. The crop has tremendous yield potential among the cereals (Badal and Singh, 1999). Maize is grown throughout the year in India and the third most important cereal crop after rice and wheat (Singh *et al.*, 2017). It accounts for 9.0 percent of total food grain production in the country, while at National level share of maize area increased from 3.5% in 1982 to 4.1% in 2010 (Birthal *et al.*, 2013). Bihar is one of the most important maize producing states in India and accounts for a substantial share in its total production (Ahmad *et al.*, 2017).

The maize crop occupy about 10.52 percent of gross cropped area (6.79 lakh ha of maize in 64.55 lakh ha GCA- IITA-maize). In the state of Bihar during the triennium ending 2008-09 to 2010-2011 the average area under maize crop was 639715 ha, production 1784860 ton and productivity was 2787 kg per hectare which increased in the triennium ending 2013-2014 to 2015-2016 to 704955 ha area, 2517100 tons production and productivity of 3571kg per hectare which is mainly due to increase in area and adoption of new technology. However, other cereal crops and coarse cereals during the same period indicated a negative growth. In Bihar, maize ranks third in terms of area and production and first position in productivity as compared to paddy and wheat (Sinha *et al.*, 2016).

Samastipur is one of the important maize producing districts of Bihar. In this district the cultivated area under maize is around 45 thousand hectares spread over three seasons varying from 12% in summer, 16% in kharif and 72% in Rabi. The production and productivity of maize in the district is around 1.64 lakh quintal with an average productivity of 36.5q/ha (DSEB, 2017). Maize crop is widely used for various purposes and each part of the plant is used both directly and indirectly, viz., grains used for human consumption, for processing industries, livestock feed, non-food products (acid, alcohols & starch) and fuels.

As per CIMA, KPMG analysis for utilization of total produced maize, it is used for poultry industries about 47% followed by direct consumption 20%, cattle feed 14%, starch purposes 12% and 7% for food processing (Patel *et al.*, 2014). Nutritionally, maize contains 60 to 68 percent starch and 7 to 15 percent protein. The yellow maize is the richest source of vitamins A. This crop is exported to other countries (21% of the total production) in 2012-13 due to demand from international markets.

Keeping in view the above, present study was undertaken to analyze maize production under the abiotic stress conditions of Samastipur district, Bihar with following objectives:

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- To assesses the existing maize production system in the district
- To find out the season- wise economics of maize production in study area
- To assess the disposal pattern of maize in the study area

MATERIALS AND METHODOS

Study area and sampling

The study is based on primary data collected from two blocks of Samastipur district through well structured and pre tested questionnaire. The district selection was purposive to capture flood and water logging scenario of maize production system and utilization pattern of maize. Samastipur faces problems of both floods and drought conditions, however, during study period; stress due to water logging was not severe. The district lies between 25055'N and 8505'E, and covers an area of about 3000 sq. km. Agriculture is the main source of income to the population. About 83% population depends on farming. The district falls under fertile indo-genetic plains, with relatively high cropping intensity. Maize, rice, wheat are the three major cereal crops of the district. As per DSEB (2017)Samastipur receives an average annual rainfall of 1205 mm and about 84 percent of net area sown is irrigated through ground water pumping. Some parts of the district are submerged due to floods and water logged from July to November every year and drought like conditions prevail kharif in some areas of the district.

Table 1: Details of the sample villages of district Samastipur Bihar

Block: Patori		Block: Vidhyapatinagar	
1.	Araiya village	1.	Bangaraha village
2.	Bhauaa village	2.	Hetimpur village
3.	Dumduma village	3.	Subhanipur village

Using stratified random sampling approach, 2 blocks on basis of highest share of maize in total cultivated area were selected for the study. Further, 3 villages were selected from each block and 20 farmers from each village were selected for detailed study, thus a total of 120 farmers selected for the present study. Survey was conducted during year 2010-11 by using structured questionnaire by trained enumerators. For analytical purpose, farmers were classified into small, medium and large categories based on the size of cultivated land. Details of the sampling process are presented in Table 1, Table 2 and Table 3 respectively.

Table 2: Farmer categorization based on land cultivated

Farm Category	Farmers selected (No)	Land cultivated in acres	
		Average / household	Range
Small farmers	40	0.37	0.04 - 0.71
Medium farmers	42	1.67	0.89 - 2.68
Large farmers	38	5.74	3.00 - 22.32
Total		120	

Table 3: Average area under maize across different farmer categories (in acres)

Season	Small	Medium	Large
Kharif	0.20 (39.0)	0.49 (22.0)	1.33 (21.0)
Rabi (Monocrop)	0.24 (13.0)	0.63 (13.0)	1.90 (11.0)
Rabi (Intercrop)	0.23 (2.2)	0.91 (8.10)	1.85 (15.90)
Summer	0.13 (0.1)	1.12 (3.70)	0.66 (2.4)

Figures in parenthesis indicate percent of cultivable land for maize.

RESULTS AND DISCUSSIONS

In the study area maize is being cultivated under diverse production systems, there are wide variations regarding the season of cultivation, and cropping pattern. The detail of crop grown by sample farmers is presented in Table 4.

Table 4: Crops grown by sample farmers season-wise

Crop	Kharif season			Rabi season			Summer season		
	% house holds	% acreage	% area irrigated	% house holds	% acreage	% area irrigated	% house holds	% acreage	% area irrigated
Maize	83	22	80	31	12	100	19	6	36
Maize Potato	0	0	NA	68	26	99	0	0	NA
Potato	0	0	NA	16	3	100	0	0	NA
Rice	78	42	76	0	0	0	0	0	NA
Wheat	0	0	NA	83	37	99	0	0	NA
Vegetables	16	5	68	18	6	73	34	11	43
Oil seeds	0	0	NA	2	<1	0	1	<1	100
Spices	5	1	70	0	0	0	3	<1	100
Pulses and Grams	9	1	43	28	6	74	61	22	66
Other crops	34	7	57	7	1	65	33	7	57
Fallow land	58	22	NA	33	9	00	77	54	NA
Total	-	100.00	74	-	100	95	-	100	83

It may be observed from Table 4, that in kharif out of total acreage, maize constitutes 22 % under 80% of irrigated area, while during rabi this crop is cultivated under 12% of GCA and total area is under irrigation. In summer around 6% areas under the crop with 36% irrigated area. Table 4 further indicates that crops like- rice, vegetable, spices, pulses and other crops are also cultivated during kharif season. However, fallow land also exists during all the three seasons, i.e. in kharif up to 22 percent of the GCA as compared to 9% during rabi and 54% during summer season respectively. Areas under fallow category was higher in kharif and summer seasons mainly due to risk involved in production of crop due to drought, flood, water logging and heavy rains during kharif and possibly due to water crisis, lower ground water table and costly agricultural operations during summers. This is evident from Table 4 that 58% farmers in kharif and 77% farmers in summer kept their land fallow, while during rabi mainly due to assured irrigation only 9% area was kept fallow by farmers due to some un-explained reasons.

Adoption of Maize Varieties by farmers:

During the field survey, it was observed that farmers were cultivating maize crop in all the three seasons i.e. kharif, rabi and summer. The details of adoption of hybrid maize varieties across the seasons and farms are presented below in Table 5.

Table 5: Adoption of maize hybrids across the season by the sample farmers

Season	Total number of farmers			Percentage of farmers growing hybrid maize		
	Small	Medium	Large	Small	Medium	Large
Kharif	28	34	37	3 (11)	1 (3)	0 (00)
Rabi	35	42	38	33 (94)	37 (88)	33 (87)
Summer	02	10	11	0 (0)	6 (60)	4 (36)
All	65	86	86	36 (55)	44 (51)	37 (43)

Note: Figures in parentheses indicate percentage

It may be observed that during all the 3 seasons, so far as small farmers were concerned, 28, 35 and 02 farmers, were growing maize and 11% in Kharif, 94% in Rabi and nil in summer season were growing hybrid maize. In case of medium farmers in 34, 42 and 10 farmers were found growing maize in kharif, rabi and summer seasons respectively out of which 3%, 88% and 60% were using hybrid seeds of maize in respective three seasons. While under large farmers' category during the kharif, rabi and summer, 37, 38 and 11 farmers were growing maize and out of which nil, 87% and 36% respectively reported use of hybrids maize with full package of practices. Overall 65 small, 86 medium and 86 large farmers across the 3 seasons grew maize, however, use of hybrid seeds was limited to 36 (55%) by small, 44 (51%) by medium and 37 (43%) by large farmers. Analysis indicates that in rabi season a large number of all existing size groups were using hybrid maize however, in kharif, use of hybrid maize was low and during summers only medium and large farmers were using the hybrid seeds. The farmers reported that the main reason for adoption of hybrid maize with full package of practices was, due to higher productivity which was possible during rabi only. But less irrigation due to lowering of ground water table in summer and water logging problem in kharif leads them not to adopt hybrid varieties on their farm. Risk involved in kharif and summer are main reasons for low adoption of hybrid variety seeds in kharif and summer.

Reason behind selecting maize variety across the seasons

The sampled farmers were asked about the reason behind selection of maize variety according to season and presented in Table 6.

Table 6: Selection of maize variety with reasons as reported by sample farmers

Season	Variety	Reasons for selection of variety			
		Yield	Adaptability	Consumption	Others
Kharif	Hybrid	50 (50%)	7 (7.14%)	7 (7.14%)	35 (35.31%)
	OPVs	5 (5.31 %)	73 (74.34%)	8 (7.95%)	14 (12.39%)
Rabi	Hybrid	101 (88.13%)	12 (10.5%)	0.0 (0.0%)	2 (1.88%)
	OPVs	62 (53.85%)	35 (30.77%)	0.0 (0.0%)	18 (15.38%)
Summer	Hybrid	15 (66.67%)	2 (8.33%)	0.0 (0.0%)	6 (25.08%)
	OPVs	0.0 (0%)	13 (57.14%)	6 (28.57%)	4 (14.29%)

The data shows that the farmers were selecting variety of maize seeds according to season and hybrid maize seed was most prominent production tool of maize. During kharif season, 50% 7.14%, 7.14% and 35.31% preferred Hybrid maize due to yield, adoptability, consumption and other purposes respectively. While during rabi it was 88.13%, 10.5%, nil and

1.88% for yield, adaptability, consumption and other purposes respectively. The corresponding figures for use of hybrid maize during summer were 66.67% for yield, 8.33% for adaptability, nil for consumption and 25.08% for other reasons. Table 6 further indicates that in kharif OPVs or local varieties were selected by 74.34% farmers for its adaptability. During rabi, selection of OPVs was 53.85% for yield and 30.77% for adaptability and 15.38% for other reasons. During summer season 57.14% farmers reported adaptability as a reason for selecting OPVs followed by 28.57% for consumption and 14.29% for other purposes. At the overall level it says that farmers were found selecting hybrid and local variety of maize as per behaviour of the seasons and the risk involve. In risk free season farmers were used hybrid variety and stress prone situation or risk condition they uses local or OPVs variety as a production risk management tools as stated by a large number of sampled farmers.

Economics of Maize production across seasons in study area

An effort has been made to work out the economics of maize production in the study area and presented in table 7.

Table: 7 Economics of Maize production across seasons in the study area.

Particulars	**Crop season**					
Cost item	**Kharif**		**Rabi**		**Summer**	
	Hybrid	OPVs	Hybrid	OPVs	hybrid	OPVs
Total cost (Rs/ha.) Paid out	6661.59	7481.63	15148.51	4848.61	13328.12	8200.40
Paid out +family labour (Rs/ha.)	8689.46	9956.57	20918.43	6797.44	16126.63	11907.87
Yield (q /ha.)	34.58	27.17	64.22	34.58	51.87	29.64
Price of grain (Rs./Q)	938	827	894	800	870	908
Gross Revenue (Rs./ha)	32436.04	22469.59	57412.68	27664	45126.89	26919.1
Net Revenue (Rs./ha) paid out	257744.45	14987.96	42264.17	22815.39	31798.77	18712
Per unit cost of production (Rs./q) Paid out.	192.64	275.36	253.88	140.21	256.95	276.66
Paid out +family labour	251.28	366.45	325.73	196.57	310.90	401.75

Note: Per unit Cost of production (paid out) is calculated from (paid out cost divided by yield) Paid out + Family labour cost divided by yield to calculated per unit cost of production with family labour

It may observed from table 7 that gross expenditure on maize production varied with season and it was Rs 6661.59 during kharif season for hybrid variety and Rs 7481.63 for OPVs. In rabi the cost incurred per hectare in hybrid maize was Rs 15148.51 and for OPVs Rs 4848.61 and in summer season the hybrid production cost was Rs 13328.12 and for OPVs it was Rs 8200.40 per hectare. The analysis indicates that the net revenue per hectare from cultivation was higher during rabi season Rs 42264.17 for hybrid maize followed by Rs 31798.77 in summer and Rs 25774.45 during kharif season. The table 7 further shows that the revenue received from local or OPVs maize production was again higher in rabi (Rs 22815.39) followed by summer (Rs 18712.72) and kharif (Rs 14987.96) respectively. Rabi maize performs better than summer and kharif maize mainly because the risks are much higher in these seasons than rabi maize due to various abiotic stresses.

Marketing of Maize

An attempt has been made to calculate season-wise maize grain yield, grain marketed price received farm categories wise in the study area and presented under table 8.

Table 8: Season-wise grain yield, grain marketed and price received

Farm Categories								
Categories	**Small**		**Medium**		**Large**		**Overall**	
Particular	**Hybrid**	**OPVs**	**Hybrid**	**OPVs**	**Hybrid**	**OPVs**	**Hybrid**	**OPVs**
Grain yield (Qt/ha.)	32.60	22.40	43.45	25039	37.94	22.28	37.62	23.37
Grain marketed (%)	0	12	72	28	64	46	51	31
Price of grain Rs/Qt.	825	800	825	789	854	794	845	793
Gross returns(Rs/ha)	26895	17920	35846.25	20032.71	32400.76	17690.32	31788.90	18532.41
Marketed returns (Rs/ha)	26895	2150.40	25809.30	5609.16	20736.49	8137.55	16212.33	5745.04
Retention (Qt)	0	15769.60	10036.95	14423.55	11664.27	9552.77	15576.57	12787.37

Table 8 presents the picture of season-wise grain yield, grain marketed and price received by different categories of farmers in the study area. The data indicated that the grain yield across the farm for hybrid varieties was found higher in medium farms (43.45 q/ha) followed by large (37.94q/ha) and small (32.60 q/ha) farms. The production was higher in medium farms mainly due to adoption of proper crop management practices by the farmer as compared to other farms.

The average grain yield for hybrid maize was 37.62 q/ha and 23.37 q/ha for OPVs varieties. The same trend was observed in gross returns marketed returns. The interesting observation is that at the overall level 51% of hybrid variety and 31% of local variety were marketed by the farmers and rest was retained for consumption and other purposes. This indicated low level of valued addition in the crop produce which is serious concern.

Thus, there is growing need for making available facilities for marketing and processing in the area.

CONCLUSIONS:

The above discussion clearly indicates that production of maize during rabi is advantageous than other two seasons mainly because of low risk of abiotic stresses in this season. While in kharif and summer seasons due to high risk and uncertainty in production, farmers use lower level of inputs leading to lower yields. It was also observed that there was gap in produce marketed and retained by farmers across, seasons and category of farms. The study further found that suitable maize production technologies for abiotic stress conditions along with suitable marketing technique are essentially required if we want to harness the full potential of maize productivity, profitability and sustainability in Bihar state.

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