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Yield Loss in Major Food Crops of Eastern India: A Review

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ABSTRACT

Yield loss is a major issue in agricultural sector seeking immediate attention in order to provide food security to continuously increasing population. An estimated loss of 23 million tonnes of food cereals, 12 milliont of fruits and 21 milliont of vegetables are reported each year, with a total estimated value of Rs 240 billion. The current review paper examines the factors causing yield loss in major cereal crops i.e rice, wheat and maize. The studies conducted by different authors on yield loss due to weed, disease & pest infestation and post-harvest loss were critically reviewed and major inferences has been drawn for eastern region. It was estimated that pre and post-harvest yield losses in rice, wheat and maize were 32.6 %, 22.65 % and 18.75 %, respectively in eastern region of the country. Using minimum support price of selected crops, the monetary loss was estimated to the tune of Rs 300 billion for rice and Rs 84.1 and 14.7 billion in case of wheat and maize. These losses can be minimized by technical interventions on farmers' field in the form of effective weed management practices, plant protection measures and controlling post-harvest loss in storage.

Keywords: Eastern India, Food grains, Monetary loss, Pre & post harvest loss, Yield

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INTRODUCTION

Food grains form an important part of the Indian diet as it is the staple food for billions of people across the globe. The production of food grains has been increasing steadily after green revolution due to adoption of high yielding varieties and advances in production technology. However, yield levels of major food grains have reached plateau now. Population is still increasing at an alarming rate in India. Fulfilling food demand of millions of people is a huge challenge. The net sown area in the country is also almost stable at around 140 million ha. Under such scenario, saving the food from losses in field and minimizing post-harvest losses is need of the hour. There are several biotic and abiotic factors affecting the crop during both pre and post-harvest stage resulting in significant losses in yield. Post-harvest losses in India amount to 12 to 16 million metric tons of food grains each year, which can feed almost one-third of India's poor. The monetary value of these losses amounts to more than Rs. 500 billion per year (Singh, 2010). According to another estimate, nearly 23 million tonnes of food cereals, 12 million tonnes of fruits and 21 million tonnes of vegetables are lost each year, with a total estimated value of Rupees 240 billion (Anonymous, 2015).

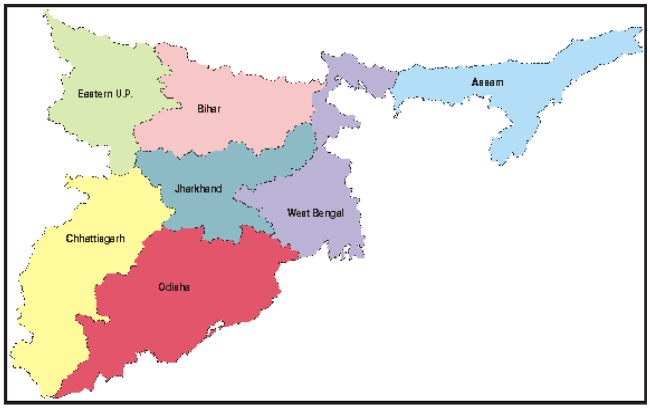

Fig. 1: Map of states of eastern region

The eastern region, comprising of seven states eastern UP, Bihar, Jharkhand, West Bengal, Assam, Orissa, and Chhattisgarh, occupies about 22.5 per cent of the country's geographical area and is inhabited by about 36 per cent of the country's population. Near about 83 per cent of the population lives in rural area therefore, agriculture is the mainstay of the economy. There is tremendous potential in this area in terms of agriculture and food security but due to several biotic and abiotic stresses the region is far behind in productivity than many other producing states in India. An effort has been made in this paper to estimate the yield loss in major food grains *i.e* rice, wheat and maize during pre and post-harvest phase.

FACTORS AFFECTING YIELD LOSS

Pre-Harvest Losses

In today's intensive agricultural input systems, reduction of economic losses in agricultural production due to abiotic and biotic factors is of the utmost importance. In eastern region of India, flood and droughts are recurring phenomena which decreases the productivity of agricultural crops. Sustaining production levels requires the development of new strategies to mitigate the ill-effects of these adverse factors. As with abiotic factors, especially lack or excess moisture during the growing season, extreme temperatures, high or low irradiance and nutrient supply, biotic stresses have the potential to reduce yields substantially. Moreover, some biotic factors *viz.* diseases, pests and weeds can also cause significant yield loss and minimizing these losses is necessary to save thousands of tonnes of food. The yield loss depends on the type of variety, stage of crop growth, pest population and

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weather conditions. It is difficult to exactly estimate the loss in yield since several factors causing yield loss are inter-related and complex in nature. According to an estimate, the worldwide loss in yield due to various types of pests was estimated as 37.4 per cent in rice, 28.2 per cent in wheat, 31.2 per cent in maize and 26.3 per cent in soybean (Oerke, 2007). In India, Dhaliwal *et al*, (2010) conducted a comprehensive study and assessed the extent of overall yield loss as 25 per cent in rice and maize, 5 per cent in wheat, 15 per cent in pulses and 50 per cent in cotton.

Post-Harvest Losses

There are several stages after harvesting before the produce reaches to the consumer. Post-harvest handling, threshing, drying, sorting, grading, packing, transport and storage are major stages in a distribution system in which some losses occur. In cereals the post-harvest loss is not much serious as horticultural crops due to relatively non-perishable in nature but it is noteworthy. As per World Bank study, post-harvest losses of foodgrains in India are 7-10 per cent of the total production from farm to market level and 4-5 percent at market and distribution level (Shah, 2013). A study showed that 3.9 to 6.0 per cent cereals, 4.3 to 6.1 percent pulses, 2.8 to 10.1 per cent oilseeds, 5.8 to 18.1 per cent fruits, and 6.9 to 13.0 per cent vegetables are lost during harvest, post-harvest operations, handling and storage in India (Nanda *et al*, 2012). Significant losses have been observed in food grains in the field and during storage due to insects, rodents, birds and other pests. On an average, out of total 6 percent loss of food grains in such storage structures, about half is due to rodents and rest is due to insects and fungi.

There are several literatures available on yield loss but most of them were site specific and only few studies were conducted at all India level. There is a lack of comprehensive review and estimate of yield loss in major crops in Eastern India. In this study, an attempt was made to assess the extent of yield loss in major crops for this region. A through literature review on factors affecting yield losses in eastern India has been done. More focus was given on studies conducted in eastern states of India like Bihar, Chhattisgarh, West Bengal, Odisha, Eastern UP, Jharkhand and Assam. Based on these studies and opinion from experts, loss in yield was estimated in terms of both quantity of produce and its monetary value. For estimation of monetary value, Minimum Support Price of respective crops announced by Government of India during year 2019-20 was taken into consideration. Rice, wheat and maize are major cereal crops grown in eastern India. Therefore, loss in yield was assessed based on studies conducted in these crops. Three major reasons of pre harvest loss i.e. weed, insects and pests were selected for this study. A post-harvest loss was also estimated based on previous works. In this study, the actual yield loss for different crops has been considered for estimation avoiding the potential yield loss.

Extent of percentage yield loss due to weed in major crops

Athorough review based on available studies was done and results were summarized in terms of extent of yield loss due to weed in different parts of India (Table 1). At all India level, it was found that generally weed causes more yield loss in rice as compared to wheat and maize. Since, most of the rice is produced as transplanted rice; weed infestation is lesser in transplanted rice than that of Direct Seeded Rice (DSR).

Table 1: Crop loss due to weed in India

Crops	Yield Loss (%)	Study Area	Reported by
Rice (transplant)	37.02	West Bengal	Mondal *et al*, 2017
Rice (transplant)	30- 36	Uttar Pradesh	Kumar *et al*, 2018
Rice (transplant)	16-86	Chhattisgarh	Garg *et al*, 2019
Rice (transplant)	80	Chhattisgarh,	Sunil *et al*, 2010
Rice (DSR)	15-90	India	Arunbabu *et al*, 2018
Rice (transplant)	10-80	India	Rao *et al*, 2014
Rice (transplant)	80	Indo Gangetic Plains, India	Singh *et al*, 2012
Rice(transplant)	50-60	India	Dass *et al*, 2017
Rice(DSR)	70-80	India	Dass *et al*, 2017
Rice(transplant)	13.8	India	Gharde *et al*,2018
Rice(DSR)	21.4	India	Gharde *et al*, 2018
Wheat	6.3-34.8	India	Kumar and Jagannathan, 2003
Wheat	10-60	India	Rao *et al*, 2014
Wheat (CT)	60.50	Chhattisgarh,	Singh *et al*, 2015
Wheat(ZT	70.0	Chhattisgarh,	Singh *et al*, 2015
Rice-wheat	25-50	Indo Gangetic Plains, India	Singh *et al*,2012
Maize	25.3	India	Gharde *et al*,2018
Maize	28-69	Jharkhand	Dewangan, 2016
Maize	34 to 62	West Bengal	Moinuddin, 2018

In case of direct seeded rice (DSR), weed infestation is more than that of transplanted rice. It is evident from various reviews that potential loss due to weed in case of DSR ranges from 21.4 to 90 per cent whereas it is less (10-80%) in case of transplanted rice (Table 1). This wider difference in yield losses might be due to the intensity and duration of the crop-weed competition which determines the magnitude of crop yield losses (Swanton *et al*, 2015; Jha *et al*., 2017). Overall, in eastern states actual yield loss due to weed was estimated as 26.6 per cent in DSR and 13.7 per cent in transplanted rice. In case of wheat majority of the studies were conducted in north-western India and very few studies were found in weed infestation in wheat in eastern region. The all-India level studies have concluded that extent of yield loss varied from as low as 6.3 per cent to as high as 70 per cent in wheat. *Phalaris minor* is major weed in case of wheat. Considering these yield losses in wheat, the potential yield loss due to weed ranges from 10 to 60 per cent. Although, productivity of maize is far better than rice and wheat, loss in yield is a cause of concern in maize crop too. Based on studies, yield loss in maize due to weed is to the extent of 25 to 35 per cent. In eastern states, loss was observed to be 27 to 60 per cent (Dewangan, 2016; Moinuddin, 2018).

Yield loss due to disease and pest infestation

Diseases and pests are major biotic factors causing yield losses in all food grains at field level. Estimation of losses caused by

individual pest or disease is very difficult since many factors affect the yield of a crop simultaneously. The extent of loss depends on variety grown, time of sowing, weather conditions, density of pest and cultural practices. As per the estimates provided by Pradhan, (1964); rice, wheat, maize suffered 10, 3 and 5 per cent loss in yield, respectively due to attack of insect pests. The loss due to insect pests has increased in post green revolution era. Crop loss estimates at all India level due to insect pests was studied by Dhaliwal *et al* (2010). According to this study, the crop loss was estimated to be 25 per cent in rice and maize, 5 per cent in wheat and 15 per cent in pulses.

Table 2: Crop loss due to disease and pest in India

Crops	Disease/ insect pest	Yield loss (%)	Study area	Reported by
Rice	False smut	5-85	India	Bhargava, 2018
Rice	False smut	15-50	Bihar	Bhargava, 2018
Rice	insect-pests	30-40	Eastern India	Heinrichs, *et al* 1986; Thakur, 1994; Jha, 1998
Rice	Rodents	10-18	Eastern India	Jha *et al*., 2012
Rice	False smut	4.3-20	Uttar Pradesh, Punjab, Bihar	Upadhyay and Singh, 2013
Wheat	Spot blotch	10-50	Indo Gangetic Plains, India	Chowdhury, 2013
Wheat	Alternaria leaf blight	up to 47	India	Singh *et al*., 2003
Wheat	Alternaria leaf blight	12.6-27.9	Uttar Pradesh, Punjab, Bihar	Singh *et al*., 2002
Maize	Banded Leaf and Sheath Blight	11-40	Bihar	Rai and Singh, 2018
Maize	*Turcicum* Leaf Blight	70.0	Uttar Pradesh, Punjab, Bihar	Jakhar *et al*., 2017

Studies conducted by various researchers on assessment of yield losses in rice, wheat and maize crop have been summarized and presented in table 5. Recent studies suggested that false smut disease in rice is major disease-causing heavy crop loss. As per studies conducted in eastern states, the potential yield loss due to this disease in rice varied from 5 to 50 per cent in eastern India. Insect pest and rodents also caused yield loss in rice to the extent of 10 to 30 per cent. In case of wheat, Alternaria leaf blight is a major disease which can causes 12.6 to27.9 per cent potential loss. Spot blotch can also cause 10 to 50 per cent yield loss in wheat. But, actual yield loss due to these diseases is 5 to 7 percent only. Maize is affected by *Turcicum* leaf blight causing up to 70 per cent loss while banded leaf and sheath blight causing 11 to 40 per cent loss in yield. Stem borer is a major pest of maize causing 26 to 80 per cent yield loss depending on severity.

Post-harvest yield loss in major food grains

Loss of food grains after harvest is a major concern in case of perishable commodities like fruits and vegetables. Food grains are relatively lesser exposed to post harvest loss due to very low moisture content. Post-harvest loss of food is defined as measurable qualitative and quantitative loss along the supply chain, beginning at harvest till its final consumption (Hodges *et al*, 2011). The quantitative loss can be measured by decreased weight or volume, while qualitative loss means reduced nutrient value and unwanted changes in taste, colour, texture, or cosmetic features of food (Buzby and Hyman, 2012).

Table 3: Extent of post harvest losses in rice, wheat and maize

Crops	Extent of post-harvest losses (%)	State	Reported by
Rice	7.3	Assam	Kannan, 2014
	5.57	Uttar Pradesh	Kannan, 2014
	3.51	West Bengal	Kannan, 2014
Rice	3.82	India	Basavaraja *et al*., 2007
Rice	2.71	India	DMI, 2002
Rice	2.32	Mizoram	Lalhmangaihchhungi, 2018
Rice	5.2	India	Nanda *et al*, 2012
Wheat	4.32	India	Basavaraja *et al*, 2007
Wheat	11.71	Assam	Kannan, 2014
	2.74	Uttar Pradesh	Kannan, 2014
	7.22	West Bengal	Kannan, 2014
Wheat	1.79	India	DMI, 2002
Wheat	6.0	India	Nanda *et al*, 2012
Maize	2.45	India	DMI, 2002
Maize	2.27	Mizoram	Lalhmangaihchhungi, 2018
Maize	4.1	India	Nanda *et al*, 2012
Maize	3.02	Karnataka	Basappa, 2007

Some studies conducted on assessment of post-harvest losses in rice, wheat and maize in eastern states and all India level is given in table 3. A comprehensive study was conducted by DMI covering 25 States, 100 selected districts and 15,000 cultivator households in the country. The extent of post-harvest losses in this study were 2.71, 1.79 and 2.45 per cent only in paddy, wheat and maize, respectively (DMI, 2002). Another recent study in eastern states concluded that post-harvest loss varied from 3.5 to 7.3 per cent in rice and 2.74 to 11.71 per cent in wheat with maximum loss occurring in Assam. In case of maize post-harvest loss was very less ranging from 1.38 to 4.1 per cent as evidenced from various studies.

Estimation of overall yield loss in major food grains

Thus, yield is affected by both pre and post-harvest factors which included both biotic and abiotic factors. Based on previous studies and opinions of experts, final estimate on yield loss for rice, wheat and maize in eastern India was calculated and presented in Table 4.

Table 4: Yield loss in major food grains due to various factors in eastern India

Major Crops	Yield loss due to various factors (%)				
	Weed	Disease	Insect pest	Post-Harvest	Over All
Rice	13.7	7.6	6.4	4.9	32.6
Wheat	8.15	5.5	4.7	4.3	22.65
Maize	6.85	3.5	5.3	3.0	18.65

Based on estimates, there is 32.6 per cent loss in yield in case of rice. Among different factors, weed causes maximum loss to the extent of 13.7 per cent. In case of wheat, loss in yield was 22.65 per cent of which weed again contributing to maximum loss (8.15%). The overall loss was minimum in maize (18.65%). In all the three crops, post-harvest loss ranged between 3 to 5 per cent only.

Estimation of state wise overall production loss in major cereals

Rice

The table 5 depicts the state wise production loss in rice in a calendar year due to weed, diseases and pest as well as post-harvest losses. It was found that due to these factors, maximum loss of rice occurs in West Bengal (Total production loss 5.13 million tonnes/year) as it contributed the major share in area and production of rice in eastern India. There was also significant production loss in Eastern UP (2.69 million tons/year) and Bihar (2.12 million tons/year). In eastern India, approximately16.5 million tonnes of rice worth Rs 300 billion is lost every year due to various factors. Strategies must be developed to minimize these losses.

Table 5: State wise production and yield loss in rice in a calendar year

States	Production* (million tonnes)	Estimated Production loss due to various factors (million-tons)	Monetary loss (in million Rs)
Assam	5.14	1.68	30412.87
Bihar	6.49	2.12	38400.68
Chhattisgarh	6.09	1.99	36033.92
Jharkhand	2.88	0.94	17040.67
Odisha	5.88	1.92	34791.37
Eastern U P	8.26	2.69	48873.59
West Bengal	15.75	5.13	93191.18
Eastern Region	**50.49**	16.46	298744.28
All India	**104.32**	34.01	617251.01

*Directorate of Economics and Statistics, Ministry of Agriculture & Statistical Abstract, Uttar Pradesh, 2019

Note: MSP of rice (2019-20) was taken as Rs. 18,150 per ton, loss extent: 32.6%

Wheat

The table 6 depicts the state wise overall loss of production in wheat. It was observed that factors reducing crop yield caused maximum loss in Eastern UP (Total production loss 2.87 million tons/year) as it has larger area and production in wheat among states of eastern India. Extent of total loss in Bihar was estimated at 1.08 million tons/year. Wheat production in Assam, Odisha, Chhattisgarh and West Bengal is very less. In eastern India, a total of 4.37 million tonnes of wheat is lost every year. The monetary value of this loss of wheat grains would be nearly Rs 84 billion. At all India level, it was estimated that 21.18 million tonnes of wheat worth Rs 408 billion was lost.

Table 6: State wise production loss in Wheat in a calendar year

States	Production* (million tons)	Estimated Production loss due to various factors (million tons)	Monetary loss (in million Rs)
Assam	0.04	0.01	174.41
Bihar	4.75	1.08	20710.59
Chhattisgarh	0.14	0.03	610.42
Jharkhand	0.74	0.17	3226.49
Odisha	0.001	0.0002	4.36
Eastern U P	12.67	2.87	55242.78
West Bengal	0.96	0.22	4185.72
Eastern Region	**19.301**	4.37	84154.77
All India	**93.5**	21.18	407671.69

* Directorate of Economics and Statistics, Ministry of Agriculture & Statistical Abstract, Uttar Pradesh, 2019

Note: MSP of wheat was taken as Rs. 19,250 per ton, loss extent: 22.65%

Maize

In case of maize crop, hybrids are very popular among

Table 7: State wise production loss in Maize in a calendar year

States	Production* (million tons)	Estimate Production loss due to various factors (million tons)	Monetary loss (in million Rs)
Assam	0.08	0.01	262.59
Bihar	2.4	0.45	7877.76
Chhattisgarh	0.19	0.04	623.66
Jharkhand	0.38	0.07	1247.31
Odisha	0.26	0.05	853.42
Eastern UP	0.45	0.08	1477.08
West Bengal	0.72	0.13	2363.33
Eastern Region	**4.48**	0.84	14705.15
All India	**21.81**	4.07	71589.14

* Directorate of Economics and Statistics, Ministry of Agriculture & Statistical Abstract, Uttar Pradesh, 2019

Note: MSP of maize (2019-20) was taken as Rs. 17,600 per ton, loss extent: 18.65%

farmers in eastern India. Problem of weed is not a major issue as 5-7 per cent actual loss in yield occurs due to weed. State wise loss in production in maize crop is estimated based on minimum support price and the same is presented in table 7.

Bihar being the highest producer of maize, 0.45 million tonnes of produce was lost in a calendar year. West Bengal was second with 0.13 million tonnes of maize being lost every year due to weed/disease/pest/post-harvest loss. Overall, in eastern states, a total of 0.84 million tonnes of maize worth Rs 14.7 billion was lost while yield loss in all India was estimated to be Rs 71.6 billion.

Table 8: Estimated yield and monetary loss in cereals in Eastern India

Crops	Estimated production loss (million tonnes)		Estimated Monetary loss (million Rs)	
	Eastern Region	India	Eastern Region	India
Rice	16.46	34.01	298744.28	617251.01
Wheat	4.37	21.18	84154.77	407671.69
Maize	0.84	4.07	14705.15	71589.14

CONCLUSION

In today's intensive agricultural input systems, reduction of economic losses in agricultural production due to abiotic and biotic factors is of the utmost importance. Moreover, some biotic factors *viz.* diseases, pests and weeds can also cause significant yield loss and minimizing these losses is necessary to save thousands of tonnes of food. The yield loss depends on the type of variety, stage of crop growth, pest population and weather conditions. In case of rice wheat and maize overall yield loss has been estimated as 32.6 %, 22.65 % and 18.75 % respectively. Monetary loss has been estimated to Rs 84 billion in wheat, Rs 300 billion in paddy and Rs 14.7 billion in maize in eastern India.

In eastern region of India, huge quantity of food grains is lost every year due to lack of crop management, disease & pest management and post-harvest handling. Weed contributes a major share in yield loss. It is therefore suggested to promote line sowing for major cereal crops like rice wheat and maize and popularizing modern weed management tools to farmers of Eastern India at low cost and subsidised rate. This will stop the potential yield loss of different major cereals and pulses as the farmers can weed out their fields with the help of well-designed weeders. Promotion of diseases and pest resistant varieties is next best alternatives which can control a huge loss to farmers. Area specific recommendation for crops based on the disease history can be prepared at block/ district level. Demand for such disease resistant varieties can be met by providing logistic support from state Govt. and seed and agrichemicals companies. Along with varieties, knowledge on plant protection through integrated disease and pest management should also be promoted to mass scale of farmers by means of digital platform as well as training and demonstrations. Post-harvest handling can also save a sizable yield loss in food grains. Here the Govt. should promote processing and post-harvest management schemes. Formation of FPO can also be very helpful in this line. The FPO can utilize proper value chain and supply chain mechanisms and can reduce yield losses

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