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Regional Analysis of the Response of Soybean to Planting Date

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ABSTRACT

Results of field experiments conducted in different agro-climatic zones during 2015 to 2017 to study the effect of planting date on soybean yield revealed that timely planting (onset of monsoon) of soybean had noticeable impact on seed yield; produced higher yield to the tune of 24.67 to 120.35 per cent across the zones. The maximum and minimum yield enhancement due to timely planting was in North Hill and Southern zones, respectively. The yield penalty due to delayed planting of soybean was to the extent of 21.15 to 44.45 kg per ha per day across the zones. The higher yield variability over the years was observed under timely planting in North Hill, North Eastern Hill and Central zones, while higher variability with late planting was in North plain, Eastern and Southern zones. Invariably, the timely planting was associated with higher sustainable yield index than late planting. Timely planting showed less than average stability in North Hill, North Eastern Hill and Central zones, while the remaining zones where late planting indicated less than average stability. The timely planting (onset of monsoon) is the most important least expensive option for augmenting the soybean productivity.

Key words: Planting date, soybean, stability, sustainable yield index, yield variation

Crop yield is mainly influenced by climatic conditions throughout the growing season, especially under rainfed conditions. The yield gaps can be reduced with better crop management, which include resorting to sowing during appropriate time period. It is known that planting date influences soybean [*Glycine max* (L.) Merrill] growth stages, due to variation in photoperiod (Han *et al*., 2006; Kumudini *et al*., 2007), air temperature (Chen and Wiatrak, 2010), and rainfall distribution and amount during the crop cycle (Hu and Wiatrak, 2012). In another study, Meotti *et al*. (2012) observed that 77 per cent of soybean yield variability was associated with the climatic conditions induced by the sowing dates.

Planting soybean too early has been shown to decrease yields (Steele and Grabau, 1997). Environmental conditions associated with late sowing affect crop features related to the capture of radiation and portioning of crop resources. These lead to lower reproductive nodes (Board *et al*., 1999), and shortening of the reproductive phases (Kantolic and Slafer, 2001). Consequently, planting soybean early allows longer vegetative and

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reproductive periods (Hu and Wiatrak, 2012), which can reduce insect and disease pressures and circumvent late-summer drought (Salmeron *et al*., 2014).

On the other hand, delayed sowing generally shifts reproductive growth into less favorable conditions with shorter days and lower radiation and temperature (Egli and Bruening, 2000). Accordingly, planting date is one of the most important and least expensive production decisions affecting soybean seed yields and quality, so it still receives considerable attention from soybean researchers (Egli and Cornelius, 2009; Hu and Wiatrak, 2012). Ultimately, Battisti and Sentelhas (2014) classified planting suitable date when actual yield overcomes the production cost in more than 80 per cent of years and mean air temperature ranges between 20 and 30 °C. But if actual yield overcomes the production cost only between 60 and 80 per cent of the years and mean air temperature does not remain between 20 and 30 °C, the planting date is classified as marginal. Planting date is considered as unsuitable if actual crop yield overcome the production cost in less than 60 per cent of the years. Therefore, sowing soybean on the best dates offer the best climatic conditions to obtain high seed yield. The aim of this study was to evaluate the effect of planting dates on yield in different agro-climatic zones of India.

METHODS AND MATERIALS

Field experiments were conducted in different agro-climatic zones, namely north hill zone (Imphal and Medziphema), north plain (Delhi, Pantnagar and Ludhiana), eastern (Raipur, Ranchi and Bhawanipatna), north eastern hill (Imphal and Medziphema), central (Kota, Sehore, Amaravati) and southern (Dharwad, Bangaluru, Coimbatore, Adilabad, Pune) during 2015 to 2017. Soybean crop was planted on the onset of monsoon (timely planting) and **[**20 days after timely planting (late planting)**]**. The crop was raised with recommended package of practices for respective zones. The data were collected from the AICRP on Soybean (Anonymous, 2015; 2016; 2017) and pooled over the locations within zone and over years. The pooled data were subjected to analyses for coefficient of variation (CV), sustainable yield index (SYI) and stability index (b). Sustainable yield index was determined as per Singh *et al*. (1990). Stability was estimated as per the procedure suggested by Finley and Wilkinson (1963). The type of stability is decided on regression coefficient (b) and mean values. If 'b' is equal to unity, the treatment is considered to have average stability (same performance in all the environments). If 'b' is more than unity, it is suggested to have less than average stability (good performance under favorable environments) and if 'b' is less than unity, it is reported to have more than average stability (good performance under poor environment).

RESULTS AND DISCUSSION

Results accrued over the centres and years revealed a perceptible variation in soybean yield in all the agro-climatic regions of India as reported below.

North hill zone

The maximum yield was observed during 2016 followed by 2017 and least in 2015. The delayed planting of soybean decreased the yield by 120.35 per cent as compared to normal planting (Table 1), which indicated the yield loss of 44.35 kg per ha per day. The yield variability over the years was less in case of late planting than timely planting. Timely planting showed higher sustainability over the late planting indicating minimum guaranteed soybean yield will be 56 per cent of the maximum yield achieved over the years. Timely planting did well under favourable environments as evidenced from the stability index which was more than unity.

North plain zone

The highest yield was recorded during 2015 and closely followed by 2017. The magnitude of yield diminution was 30.31 per cent over late planting and indicated a yield reduction of 22.75 kg per ha per day. Soybean yield variation was found to be higher under delayed planting than timely planting. The maximum sustainability yield index was associated with timely planting; the minimum guaranteed yield will be 73 per cent of maximum yield achieved during the three years. Timely planting performed very well under unfavorable environments while late planting did well under favourable environments.

North eastern hill zone

The congenial weather conditions during 2015 resulted in the maximum soybean yield as compared to 2017 and 2016. Timely planting produced higher yield (25.09 %) over late planting, which resulted in yield reduction of 27.25 kg per ha per day. The higher yield variation was observed under timely planting than late planting. The minimum guaranteed yield will be 61 per cent under timely planting as compared to late planting (47 %) as evidenced from the sustainable yield index. Timely planting showed average yield stability over the years, while late planting performed very well under unfavourable environments.

Eastern zone

The maximum yield was noted in 2016 followed by 2017 and 2015. Delayed planting showed a yield loss of 46.85 per cent as compared to timely planting and indicated a yield penalty of 28.65 kg per ha per day. The difference in yield variation between two planting dates was found to be negligible. Timely planting possessed higher sustainability yield index than late planting. Late planting showed average stability indicating that the yield performance was uniform over the years, while timely planting performed very well under unfavourable environments.

Central zone

The highest yield was recorded during 2016, while yield performance was more or less the same during remaining two years. The timely planting of soybean produced higher yield by of 83.08 per cent, which indicated a yield loss of 35.35 kg per ha per day due to late planting by 20 days. The yield variation under timely planting was higher than late planting. Timely planting was more sustainable than late planting and

Table 1. Impact of planting date on soybean productivity in different agro-ecological zones

Planting date	Year			Mean	Coefficient of variation	Sustainable yield index	b
	2015	2016	2017				
North Hill Zone							
Timely	1128	2059	1686	1624	39.67	0.56	1.70
Late	657	811	742	737	6.53	0.32	0.27
Mean	**893**	**1435**	**1214**	**1181**			
North Plain Zone							
Timely	2130	1542	2197	1956	20.84	0.73	0.85
Late	1883	965	1654	1501	27.64	0.47	1.13
Mean	**2007**	**1254**	**1926**	**1729**			
North Eastern Hill Zone							
Timely	2709	1838	1901	2149	25.11	0.61	1.03
Late	2218	1332	1604	1718	23.47	0.47	0.96
Mean	**2464**	**1585**	**1753**	**1934**			
Eastern Zone							
Timely	1407	2105	1876	1796	23.56	0.68	0.97
Late	970	1648	1052	1223	24.51	0.41	1.01
Mean	**1189**	**1877**	**1464**	**1510**			
Central Zone							
Timely	1347	1801	1525	1558	19.00	0.74	1.58
Late	898	925	730	851	8.78	0.41	0.48
Mean	**1123**	**1363**	**1128**	**1204**			
Southern Zone							
Timely	1952	2334	-	2143	13.99	0.80	0.96
Late	1518	1919	-	1719	14.68	0.61	1.01
Mean	**1735**	**2127**	**-**	**1931**			

Timely- onset of monsoon, Late- 20 days after normal

indicated that the minimum guaranteed yield will be 74 per cent of the maximum achievable yield over the years. Timely planting with higher stability index than unity indicated that soybean performed very well under favourable environments, while late planting performance was better under harsh environments.

Southern Zone

The experiment was conducted for two years only (2015 and 2016). The maximum yield was recorded in 2016.

Timely planting produced higher yield to the extent of 24.67 per cent and delayed planting caused a yield reduction of 21.15 kg per ha per day. Late planting showed higher yield variation than timely planting. The maximum sustainable yield index was associated with timely planting indicating a minimum guaranteed yield will be 80 per cent of the maximum yield achieved over the years. Late planting indicated average stability means performed well under all the environments, while timely planting performed very well under unfavourable environments.

Different soil properties and weather conditions at the different locations might have contributed to the differences in seed yield among the six agro-climatic zones under consideration. Environmental conditions can change the yield in the same sowing date in different years; therefore, just one field experiment cannot bring conclusive results for choosing the best sowing date (Egli and Cornelius, 2009).

With planting delay the growth period becomes short, while high temperature during flowering decreases the seed yield and yield components of soybeans planted early. No doubt, the duration of the vegetative stage, reproductive stage, and total growing period were extended by early planting, compared with those in timely planting. Early planting extended the duration of the reproductive stage more than that of vegetative stage (Chen and Wiatrak, 2010).

On the other hand, the planting delay decreased the yield (Kane *et al*., 1997; Board *et al*., 1999; Egli and Bruening, 2000; Kantolic and Slafer, 2001). Yields decreased at a faster rate after the optimal planting date, primarily because of decreased vegetative and reproductive growth that reduced the number of branches and pods, decreased plant height, and reduced photosynthesis (Popp *et al*., 2002; Pedersen and Lauer, 2003; Bastidas *et al*., 2008; De Bruin and Pedersen, 2008). Similar results were also reported by Billore *et al*., (2000, 2009) and Billore and Srivastava (2013).

On the basis of foregoing results it could be concluded that the timely planting of soybean is a best least expensive option for achieving the sustainable higher yield.

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