Comparative Study on Yield Variability and Phosphorus Fertilizer Use Trends in the Established and Emerging Maize-growing Districts of Telangana

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Maize is an important cereal crop grown in 8 out of 10 districts in the newly formed state of Telangana, with surveys identifying yields ranging from 2.9 to 7.4 t/ha.

The yield trends and P fertilizer use by farmers were found to be correlated to socio-economic determinants of the farmers in the study area, suggesting the need for integrating farmers' socio-economic factors, along with bio-physical characteristics of farms, while designing intervention strategies to rationalize fertilizer use in maize.

Agriculture is one of the major important sectors contributing to the economy of the new state of Telangana. The state has about 5.7 million (M) ha cropped area under food and non-food crops. Maize is grown in 8 out of the 10 districts of the state, with an area of 0.64 M ha, occupying 11.3% of the total cropped area (Telangana statistics, 2013). The large poultry-farming sector in Telangana and adjacent states are the major consumers of maize grain, with the poultry feed assured market in this sector contributing to the increase in cultivated area under maize. The state produces 2.6 M t of maize grain with a productivity of 4.6 t/ha (**Table 1**), which is

Table 1. Area, Production and Productivity of maize in Telangana.

District	Area, ha	Production, t	Productivity, kg/ha
Adilabad	22,020	68,773	3,123
Karimnagar	108,706	568,675	5,231
Khammam	32,057	172,456	5,380
Mahabubnagar	118,589	55,000	4,729
Medak	142,205	643,031	4,522
Nizamabad	94,834	505,743	5,333
Ranga Reddy	42,971	166,701	3,879
Warangal	80,092	387,607	4,840
Total	641,474	2,567,986	4,630

Source: (http://www.telangana.gov.in)

80% higher than the national maize productivity (FAI statistics, 2014). Maize is considered both as an established and emerging crop in the state with respect to the expansion of area under maize owing to its higher yield potential and its adaptability to multiple seasons under different ecologies.

Fertilizer nutrient use in Telangana during 2013-14 was 1.34 M t, of which N, P_2O_5 and K_2O use accounted for 73, 21 and 6%, respectively (FAI, 2014). The nutrient use in southern India indicated a wide range of P_2O_5 application (38 to 230 kg/ha) in maize. An earlier study by Satyanarayana et al. (2012) suggested that farmers' perception-based fertilizer application often exceeds economic rates of P_2O_5 application. The authors attributed such inappropriate application of P_2O_5 to lack of awareness among maize growers about appropriate fertilization

Abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium.

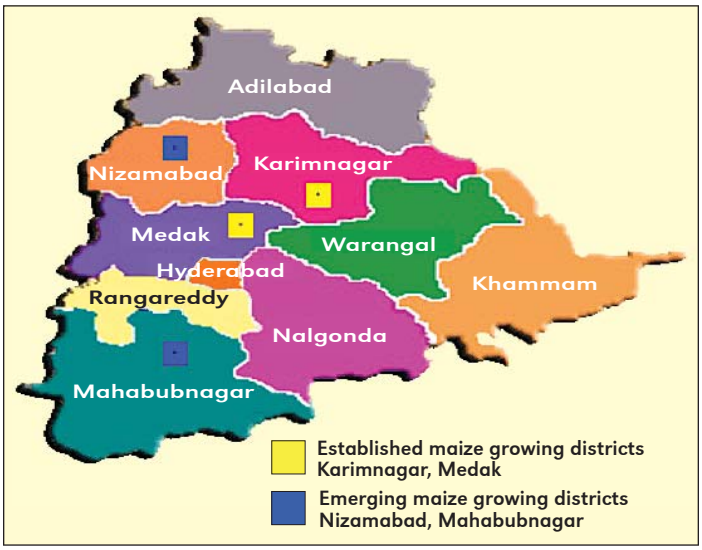

Figure 1. Collaborative project study area in Telangana state.

in hybrid maize in general, and about P requirement of maize in particular. Generally, farmers use complexes as the sources of P fertilizer, applied both at the time of planting and through top dressing at various stages of crop growth. As a result, P is applied throughout the growing season without knowing the crop's demand, or the right time of P application, that leads to uneconomical use of P fertilizer by farmers. Jat et al. (2012) reported an average maize yield response of 853 kg/ha in omission plot studies, and a ROI of 2 Rs/Re even with ample application rates of P in the trials, indicating the importance of P application in maize. The socio-economic determinants of farmers often significantly influence their fertilizer application decisions (Banerjee et al., 2014), leading to variation in farmers' yields. So improved fertilizer decision support in maize must integrate both biophysical characteristics of farms and socio-economic factors of farmers to achieve the twin goals of improved productivity and improved farm profitability in smallholder systems of maize cultivation. The current study investigates the P fertilizer use by farmers in maize and their associated socio-economic factors in determining the maize yield variability of the state.

A joint collaboration was established between Professor Jayashankar Telangana State Agricultural University (PJTSAU) and International Plant Nutrition Institute (IPNI) to initiate a study on agronomic, economic, social and environmental

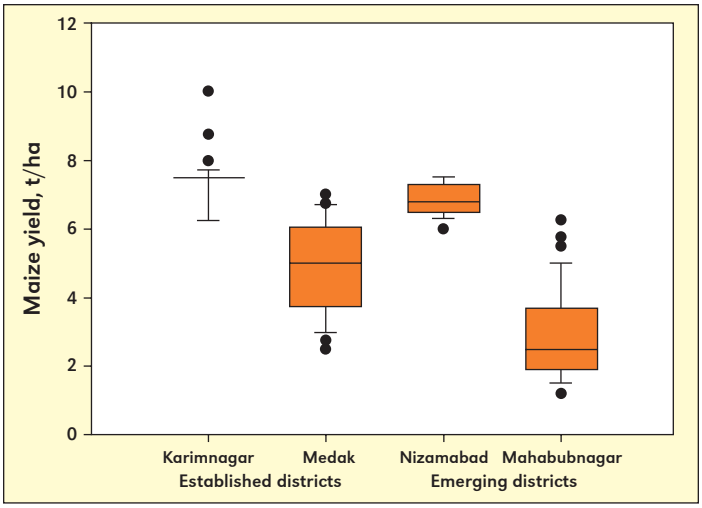

Figure 2. Yield variability in the established and emerging maize-growing districts of Telangana. Boxes represent data within the first and third quartiles (interquartile range). The line inside the box denotes the mean. Lines extending beyond the interquartile range denotes the 10th to 90th percentiles of the data. Statistical outliers are plotted as individual points outside these lines.

benefits of improved nutrient management practices in maize production systems under variable farm size, climate, soil fertility conditions and farmer resource endowment in Telangana. This paper considers a part of the study, which discusses the maize yield variability and P fertilizer use trends in four districts of Telangana and its associated relationship with different socio-economic aspects of farmers.

A rapid rural survey, to assess socio-economic and biophysical aspects of farmers, was conducted in four maize-growing districts of Telangana. Based on the criteria of area under maize cultivation, prevailing yield levels, and access to water while growing crops (irrigated or rainfed situations), two established and two emerging maize growing districts were selected. Of the eight major maize-growing districts in Telangana (**Table 1**), Karimnagar and Medak are chosen as the established districts while Nizamabad and Mahabubnagar are considered as the emerging districts (**Figure 1**). Karimnagar and Nizamabad falls under northern Telangana zone, with red earth soil type having a mix of loamy soils (Chalkas) and black cotton soils and with an annual rainfall of 900 to 1,150 mm. Medak district comes under central Telangana zone while Mahabubnagar is in southern Telangana zone with normal rainfall of 800 to 1,150 and 500 to 670 mm, respectively. The soil type in Medak was red earths with loamy texture (chalkas), red sandy soils and black cotton soils in pockets whereas the soil type in Mahabubnagar was predominantly red soils with chalkas.

Three villages in each of the selected districts were chosen in consultation with the experts from the agricultural university and staff of the department of agriculture. Villages with high maize acreage under the identified maize-growing seasons were selected for the survey. A total of 15 maize farmers in the villages were then selected for a detailed survey through systematic sampling. The number of maize farmers in each village (n) was divided by fifteen (n/15 = k), where k represented the frequency of sampling or the number of households between surveyed households. The farmers in each village were interviewed on socio-economic profile, farm profile, farm asset inventory, crop management practices, maize production related problems, soil resource use, and water resource use. From the survey, information on maize yield variability and the extent of P fertilizer use were determined in addition to identifying the major socio-economic factors responsible for higher maize yields in the study region.

Maize Yield Variability in Telangana

The survey indicated high maize yield variability among farmers in the established and emerging maize-growing districts of Telangana (**Figure 2**). In the established maize-growing districts, grain yield varied from 6.25 to 10 t/ha with a mean yield of 7.4 t/ha in Karimnagar. In Medak district, the grain yield ranged from 2.5 to 7.0 t/ha with an average yield of 4.91 t/ha. The higher yield in Karimnagar may be attributed to a high average rainfall (1,025 mm) as compared to 975 mm in Medak district. Also, the rainfall productivity (kg yield per mm of rainfall) of Karimnagar (7.2) is higher than Medak (5.0), and all the surveyed farmers in Karimnagar have access to deep bore well and farm ponds, whereas, only 46% of farmers in Medak district have access to bore well as an alternative source of irrigation to maize crop. From the survey, it was revealed that an average maize farmer in Karimnagar practicing farming for 23 years have the experience of growing maize for almost the same period (average of 21.5 years). In Medak, even though most of the farmers have farming experience of more than 23 years, they have the experience of growing maize only for the last 10 years (**Figure 3**). The longer experience of Karimnagar

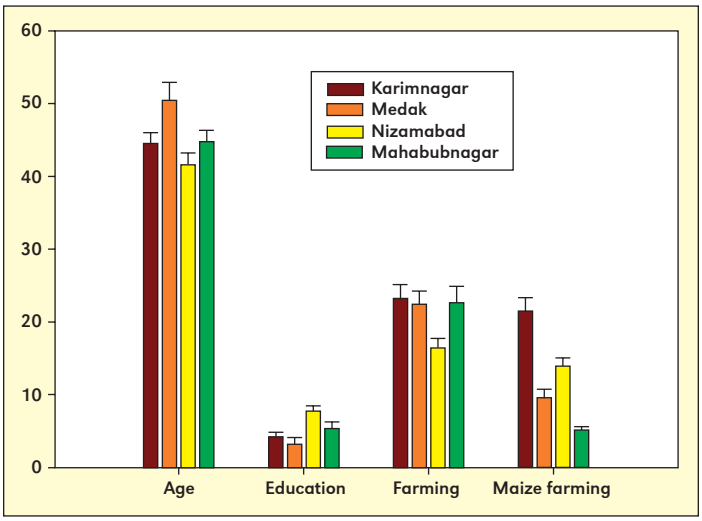

Figure 3. Characteristics of maize-growing farmers in Telangana. Age, farming and maize farming are in years and education is shown as grade level.

farmers may have helped them fine tune agronomic practices that attributed to higher maize yield over the farmers in Medak district.

In the emerging maize-growing districts of Telangana, maize yield in Nizamabad averaged 6.83 t/ha and ranged from 6.0 to 7.5 t/ha, indicating a narrow variability among the maize-growing farmers in the district (**Figure 2**). Maize yield in Mahabubnagar averaged 2.91 t/ha and ranged from 1.2 to 6.25 t/ha, registering the lowest maize yield among the four districts considered under the study. The survey indicated that the respondent farmers have the experience of growing maize

Table 2. Fertilizer nutrient use (kg/ha) trends in maize growing districts of Telangana.

	---- N ----		---- P_2O_5 ----		---- K_2O ----		
District	Range	Mean	Range	Mean	Range	Mean	Total
Karimnagar	80-286	201	0-150	76	30-300	127	404
Medak	140-488	228	75-473	131	0-150	42.5	402
Nizamabad	208-260	234	64-80	73	32-40	36	343
Mahabubnagar	75-620	207	0-230	100	0-30	0.7	308

only during the last five years even though they have been growing crops over the last 23 years (**Figure 3**). The survey also indicated that farmers in this district grow maize only during kharif season, completely dependent on rainfall, and keeping the land fallow during the rest of the year. Mahabubnagar is the second largest district in Telangana growing maize next to Medak (**Table 1**) and based on the survey data, it was observed that farmers have the experience of growing maize in the last five years even though they have the farming experience of more than 20 years (**Figure 3**). From this observation, it may be inferred that the majority of area expansion under maize has happened in the recent past indicating maize as the potential option of crop diversification during the kharif season where crop is grown predominantly under the rainfed situations.

Fertilizer Use Trends in Telangana

Data in **Table 2** and **Figure 4** showed the fertilizer use trends in the surveyed region. **Table 2** indicated that the total nutrient use ($N+P_2O_5+K_2O$) in the maize-growing districts of Telangana was highest in Karimnagar (404 kg/ha), followed by Medak (402 kg/ha), Nizamabad (343 kg/ha) and Mahabubnagar (308 kg/ha). Whereas, the partial factory productivity, an indicator of productivity of maize crop in comparison to its nutrient input, was highest in Nizamabad (19.9) followed by Karimnagar (18.3), Medak (12.2) and Mahabubnagar (9.4), respectively. This gives an indication that farmers in Nizamabad and Karimnagar followed a generally better fertilizer application strategy, which is probably associated with the experience of maize farming. Farmers in Karimnagar growing maize during the last 22 years had a better understanding of the importance of K response in maize and thus applied adequate K_2O rates to an extent of 127 kg/ha (**Figure 4**). Similarly, farmers of Nizamabad, owing to higher education (average of Grade 8) and long experience of maize farming (average of 14 years), understood the importance of balanced fertilization and restricted the nutrient use to a narrow range of 208 to 260, 64 to 80 and 32 to 40 kg/ha of N, P_2O_5 and K_2O, respectively (**Table 2**). Maize-growing farmers in Medak and Mahabubnagar district applied imbalanced rates of N (140 to 488 and 75 to 620 kg/ha, respectively) and P_2O_5 (75 to 473 and 0 to 230 kg/ha, respectively) and neglected the application of K_2O (0 to 150 and 0 to 30 kg/ha, respectively), which resulted in unbalanced application of nutrients and led to lower maize productivity of 4.91 and 2.91 t/ha (**Figure 2**), respectively.

Figure 4 also illustrated that the P fertilizer use was 19, 33, 21, and 32% over the total nutrient use in Karimnagar, Medak, Nizamabad, and Mahabubnagar districts, respectively. The higher P_2O_5 use in Medak and Mahabubnagar districts was found to be due to top dressing of P through the use of complex fertilizer sources. This indicated that farmers in this region

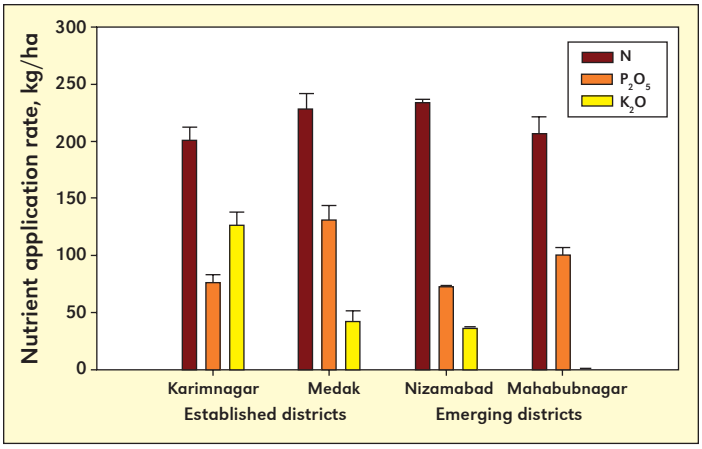

Figure 4. Fertilizer (N, P_2O_5, K_2O) use trends in maize-growing districts of Telangana.

were not aware of the right timing of P fertilizer use in maize. The above discussion indicates a lack of awareness about the 4R principles among the maize-growing farmers in Medak and Mahabubnagar districts, which provides opportunities for improving nutrient management in maize through 4R education.

Relationship between Maize Yield and the Socio-economic Aspects of Farmers

In Karimnagar, the yield of maize was significantly and positively correlated with the age of farmers and farm income, whereas, negatively and significantly correlated with the non-farm income (**Table 3**). This probably confirms that experience of farmers and investment from farm income helps maize yields in Karimnagar. Negative correlation between maize yield and non-farm income suggests that farm families more dependent on non-farm income probably put lesser attention to agronomic practices, adversely affecting maize yields. However, maize grain yield was negatively and significantly correlated with the age of the farmers in Nizamabad and Mahabubnagar. The average age of farmers in Nizamabad was 41 (ranged from 24 to 70) and the average yield of maize (**Figure 2**) was the second largest (6.8 t/ha, next to Karimnagar) among the surveyed districts. This indicated that the young farmers in the district contributed to higher maize yield in Nizamabad, which was categorized as the emerging maize-growing district. In Mahabubnagar, the average age of the farmer was 45 and the average maize yield was 2.9 t/ha. The negative correlation between yield and farmer age probably indicated that the older farmers were associated with maize growing and there is a need to encourage young farmers to become involved in farming for improving the productivity of maize in Mahabubnagar.

In Nizamabad, farm income, total income and farm size were negatively and significantly correlated with maize yield (**Table 3**). This indicated that the small farmers with low farm or total income produced higher maize yields, whereas big farmers with high income obtained lower maize yields. This trend suggested that achieving high maize yields is a top priority for small farmers for their sustenance, and interventions should aim at efficient utilization of available resources to maintain high, profitable maize yield. Bigger farmers with higher incomes have opportunities to improve maize yield through higher investment and better yield targeting. In Karimnagar and Mahabubnagar, farmer's income was positively and

significantly correlated with maize yield suggesting higher investment in maize production (**Table 3**). The negative and significant correlation between the P fertilizer use and years of farming in Medak and Mahabubnagar indicated that farmers applied higher doses of P, most likely due to P use throughout the cropping season, as a result of less experience in maize farming. Interventions to improve awareness among the farmers about 4Rs of P fertilizer use in the maize-growing districts of Medak and Mahabubnagar may improve farm profitability.

Summary

The above study helped in understanding the maize yield variability and the fertilizer use trends in the two established and the two emerging maize-growing districts of Telangana. The relationship between the maize yield and the socio-economic aspects of farmers was also well established. We believe that there are opportunities to rationalize fertilizer recommendations based on 4R principles and farmer socio-economics to improve the productivity and profitability of maize production in the newly formed state of Telangana. BCSA

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Scientists of IPNI, CIMMYT and PJTSAU interacting with the farmers during a survey in Nizamabad district of Telangana.

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Table 3. Relationship of maize yield and P fertilizer use with different socio-economic factors of farmers in maize growing districts of Telangana.

District	Parameter	Relationship	Age	Education	Years of farming	Farm income	Non-farm income	Total income	Farm size
Karimnagar	Maize yield	r value	0.276	-0.281	ns	0.759	-0.637	ns	ns
		p-value	0.055	0.026		0.04	0.07		
	P_2O_5	r value	ns	ns	ns	ns	ns	0.167	ns
		p-value						0.027	
Medak	Maize yield	r value	ns	0.305	ns	ns	ns	ns	0.431
		p-value		0.01					0.017
	P_2O_5	r value	ns	0.357	-0.381	ns	ns	ns	0.347
		p-value		0.05	0.03				0.05
Nizamabad	Maize yield	r value	-0.776	ns	ns	-0.583	ns	-0.693	-0.841
		p-value	0.04			0.04		0.04	0.03
	P_2O_5	r value	-0.771	ns	-0.495	0.495	-0.261	-0.731	ns
		p-value	0.04		0.01	0.01	0.03	0.05	
Mahabubnagar	Maize yield	r value	-0.299	ns	ns	0.377	0.347	0.368	0.249
		p-value	0.045			0.01	0.01	0.012	0.013
	P_2O_5	r value	ns	ns	-0.249	ns	ns	ns	ns
		p-value			0.05				

The pair (s) of variables with positive correlation coefficients and *p* values below 0.05 tend to increase together. For the pairs with negative correlation coefficients and *p* values below 0.05, one variable tends to decrease while the other increases. For pairs with *p* values greater than 0.05, there is no significant relationship between the two variables. ns indicate non-significant.