Corn Revolution in Andhra Pradesh: The Role of Single Cross Hybrids and Zero Tillage Technology

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Correct Citation: Jat, M.L., Dass, S., Sreelatha, D., Sai Kumar, R., Sekhar, J.C. and Chandana, P. 2009. Corn Revolution in Andhra Pradesh: The Role of Single Cross Hybrids and Zero Tillage Technology. DMR Technical Bulletin 2009/5. Directorate of Maize Research, Pusa New Delhi, PP. 16

Published in 2009

Published by : Project Director
Directorate of Maize Research
(Indian Council of Agricultural Research)
Pusa Campus, New Delhi-110 012

Printed at : Embee Creation
WZ-572 A, Naraina Village,
New Delhi-110 028

DMR Technical Bulletin 2009/5

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Introduction:

Maize, the most versatile crop with wider adaptability in varied agro-ecologies has highest genetic yield potential among the food grain crops. In India, despite major chunk of maize farming concentrating in marginal environments, maize contributes more than 8 % in the national food basket Maize also contributes over Rs. 100 billion to the agricultural GDP at current prices apart from the providing employment to over 100 million man-days at the farm and downstream agricultural and industrial sectors. As the demand for maize is growing globally due to its multiple uses for food, feed and industrial sectors, we need to produce more from same or even less resources which can be achieved through targeting technologies in potential regions.

The Andhra Pradesh is the non-traditional maize growing state but, the climate of the state is very favourable for the maize crop and hence maize can be grown in any season in the state. However, it was mainly grown as a rainfed crop during monsoon season concentrated mainly in Telangana region.

The trends in area, production and productivity of maize in Andhra Pradesh has shown a remarkable increase during past 6 decades. During 1950-51, the maize acreage in the state was very less (1.4 lakh ha) that has grown up by 5.7 times to the present (2007-08) level of 7.9 lakh hectares. However, the production has increased dramatically from merely 40 thousand tones during 1950-51 to 41.4 lakh tones during 2007-08 (Figure 1) which is nearly 109 times higher. Similarly the productivity of maize in the state was merely 275 kg ha^{-1} during 1950-51 that has increased to 5240 kg ha^{-1} during 2007-08 which is highest state average in the country. Trends shows that till 1990's the growth in area, production and productivity of maize was very slow but thereafter it took momentum. However, the major increase was achieved during past few years mainly due to adoption of single cross hybrids and shift in acreage under non-traditional areas.

Photo 1. A view of single cross hybrid maize field in Guntur, AP

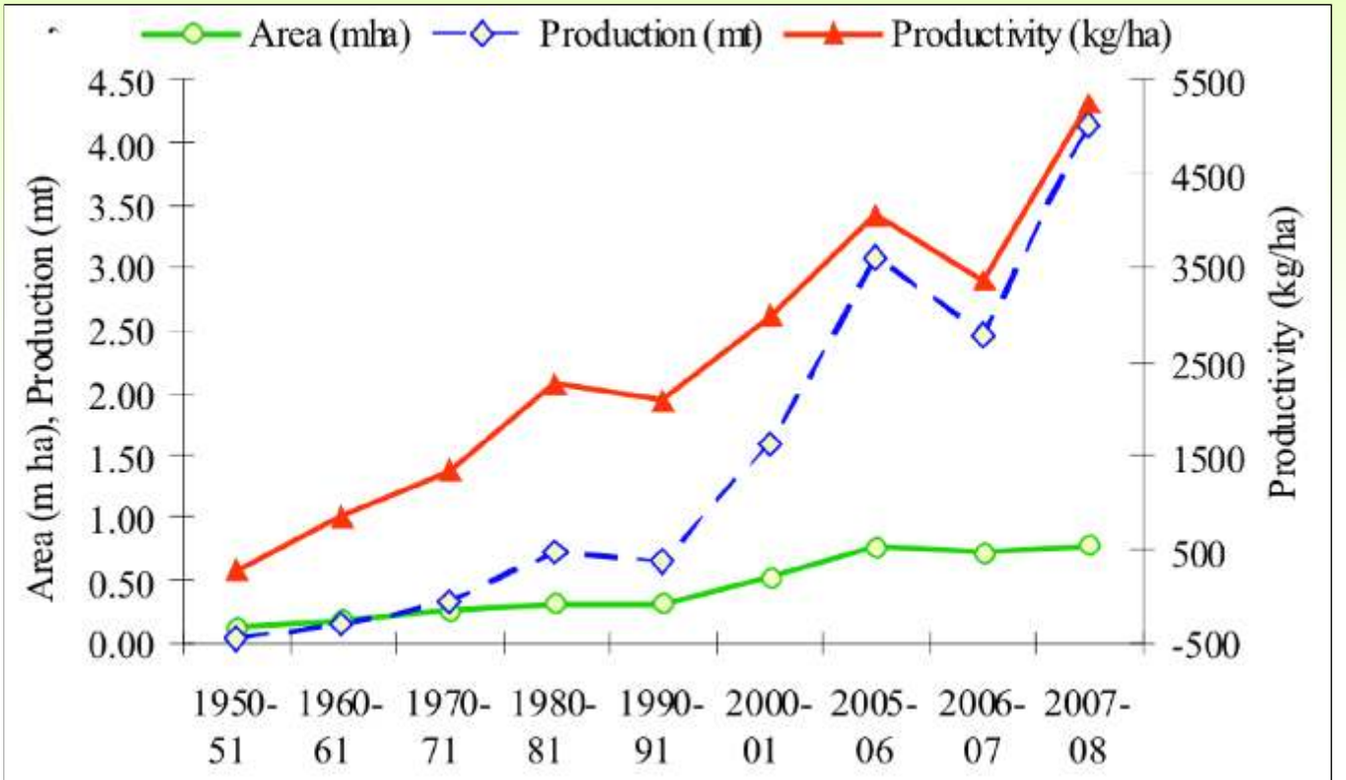


Figure 1 Trends in area, production and productivity of maize in Andhra Pradesh

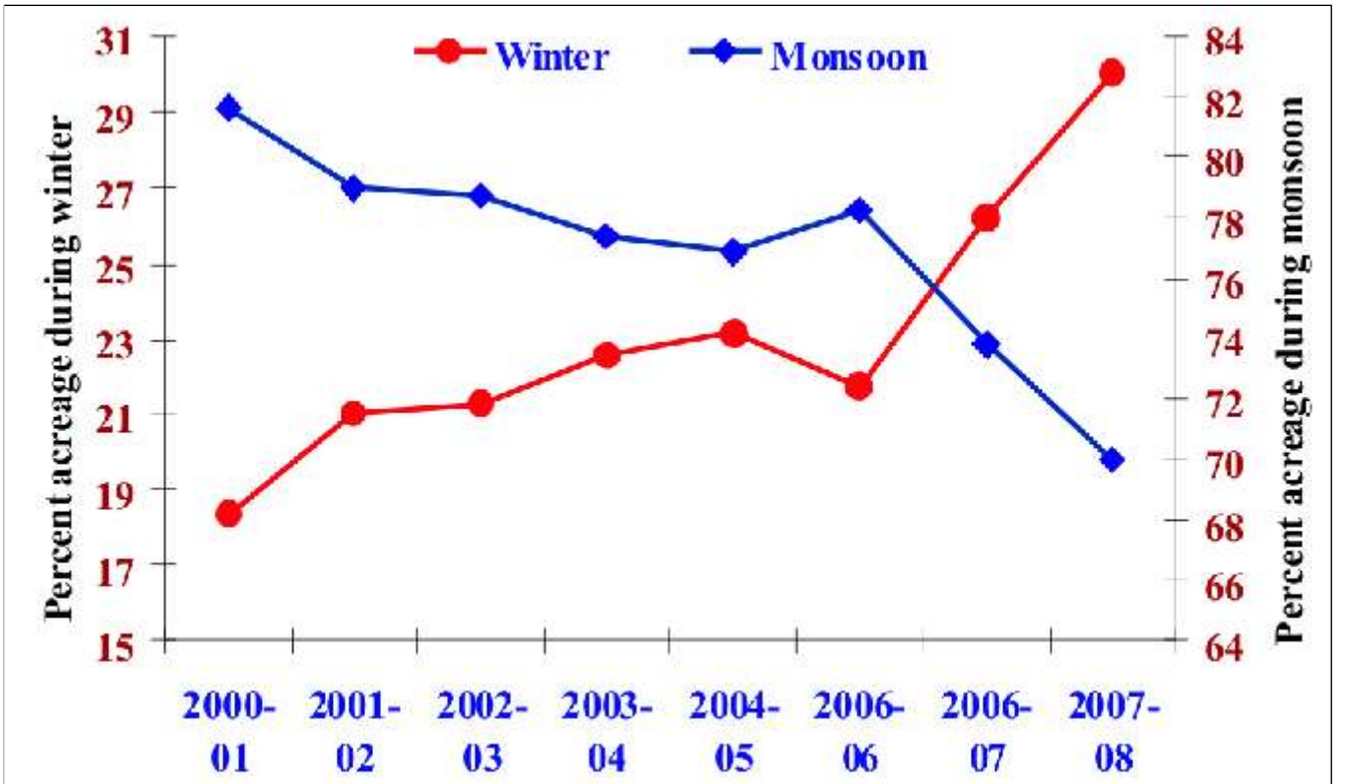


Figure 2 Trends in share of corn acreage during monsoon and winter seasons in Andhra Pradesh

Recent trends in seasonal acreage of maize in Andhra Pradesh showed a dramatic change during past one decade. Figure 2 shows that during 2000-01, the maize acreage during monsoon season was 82 % that has decreased to 70 % during 2007-08. Whereas, the acreage during winter has grownup from merely 18 % during 2000-01 to nearly 30 % during 2007-08 (Figure 2). This shows that maize is occupying more acreage under non-traditional season as well as non-traditional areas that indicates that maize is emerging as one of the potential driver for crop diversification in the state. Moreover, the winter maize is more assured crop with higher productivity potential compared to monsoon season. Therefore, in areas where winter rice crop suffers due to water scarcity, the maize has emerged as potential alternative like Guntur, Krishna, and west Godavari districts.

As discussed above, the Andhra Pradesh though is a non-traditional maize growing state but has emerged as one of the potential maize growing state that contributes nearly 21 % of the total maize production in the country. For over a decade during 1980-81 to 1990-91, there was a decreasing trend in area, production and productivity of maize in the state. However, since 1990's there has been a perceptible increase in area, production and productivity mainly due to adoption of hybrids in the state. But, the major gain in productivity was noticed since past 2 years mainly due to cultivation of 'Single Cross Hybrids' (SCH) and shift of maize area under non-traditional regions mainly no-till maize in rice-maize systems. These two technologies are able to address the issues of water scarcity in intensive irrigated regions of Krishna and Godavari zones and also the SCHs experiences better productivity even in the scarce rainfall areas like Ananthpur.

Efforts has been made through this publication to summarize the maize revolution in Andhra Pradesh as well as adoption and impact of 'Single Cross Hybrids' and 'Zero-Tillage' technologies in maize along with future actions needed to sustain this revolution in the state.

Photo 2. Farmer-scientist interface on SCH technology

Table1 Major soil types, cropping intensity and irrigation intensity in different agro-climatic zones of Andhra Pradesh

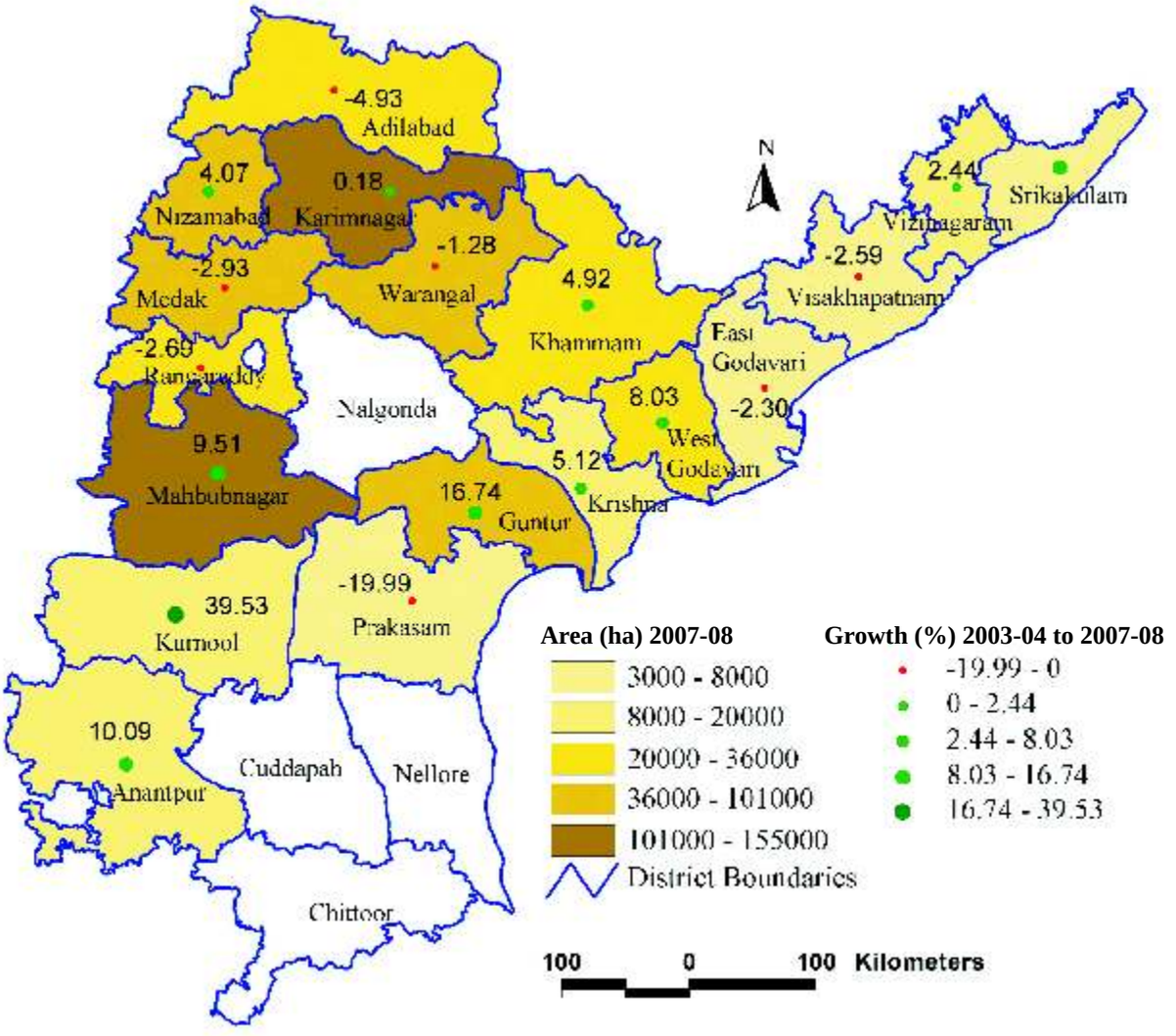
S. No.	Name of Zone	Districts	Major soil types	Cropping intensity (%)	Irrigation intensity (%)
1	North Coastal zone	Srikakulam, Vizianagaram, Visakhapatanam	Alluvial, red sandy loams, red loams with clay based coastal sands, lateritic soil	132	116
2	Godavari Zone	East and West Godavari	Black cotton soils, coastal sands, red loams	173	172
3	Krishna zone	Krishna, Guntur, Prakasam	Red, heavy black, light black, red chalka, coastal sand, problem soils	131	122
4	Southern zone	Cuddapha, Nellore, Chitoor	Red soils, black soils, alluvial, sandy soils, coastal sand, laterritic soils, problem soils	116	124
5	Northern Telangana zone	Adilabad, Karimngar, Nizamabad	Red sandy, red earth with loamy sub soil, lateritic soil, black cotton, forest soils	135	160
6	Central Telangana zone	Warangal Khammam and Medak	Red sandy, red earths with loamy sub soil black cotton, forest soils, problem soils	121	107
7	Southern Telangana zone	Mahbobnagar, Nalgonda, Ranga reddy	Red sandy soils, red earth, black cotton soils, problem soils	115	137
8	Scarce rainfall zone	Ananthpur	Deep black light, black road earth with clayey sub soil, red loamy soils, red earth with loamy sub soil, red sandy soils, problem soils	108	123
9	High altitude tribal zone	High altitiude tribal areas of Srikakulam, Vizianagaram East Godavari Adilabad and Khammam	Alluvial, red sandy loam, red loam with clay base, coastal sands and forest	120	110

Agro-climatic features of Andhra Pradesh:

The Andhra Pradesh has diverse soil and climatic conditions and has been divided in to nine agro-climatic zones (Table 1). The soils in the state varied greatly between and within agro-climatic zones with wider coverage under red and black soils. The average cropping intensity of the state is about 128 % with highest (173 %) in Godavari zone and lowest being 108 % in scarce rainfall zone. Similarly, the average irrigation intensity of the state is 130 % with highest being 172 % in Godavari zone and the lowest being 107 % in central Telangana zone (Table 1). The maximum acreage under maize is in Telangana region having red soils wherein the cropping intensity and irrigation intensity varies from 115 to 135 % and 107 to 160 %, respectively. However, during past few years, the maize has emerged as a potential crop under Godavari and Krishna zones having black soils.

Spread and growth rate of area, production and productivity of maize:

The map (Map 1) shows the spread of acreage (2007-08) under maize in different districts of Andhra Pradesh. The growth rate of maize acreage in the state during 2003-04 to 2007-08 varied from -20 to nearly 40 %. The Ranga Reddy, Adilabad, Medak, Warrangal, East Godavari, Prakasam and Visakhapatanam dismcts showed negative growth rate of maize acreage. However, the acreage in these districts is very less. The Kurnool, Guntur, west

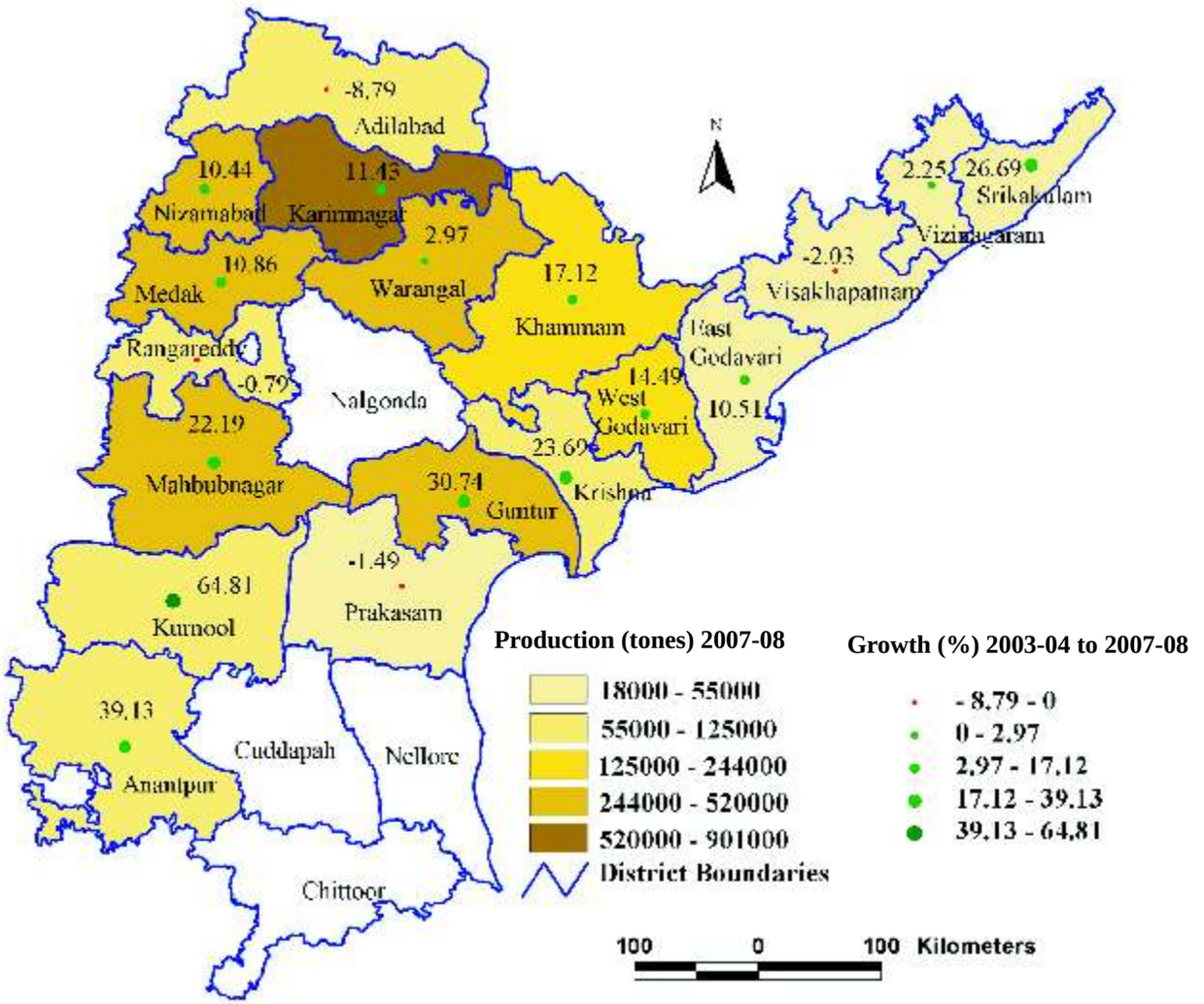


Map 1 District-wise area (2007-08) & growth rate (2003-04 to 2007-08) of maize in Andhra Pradesh

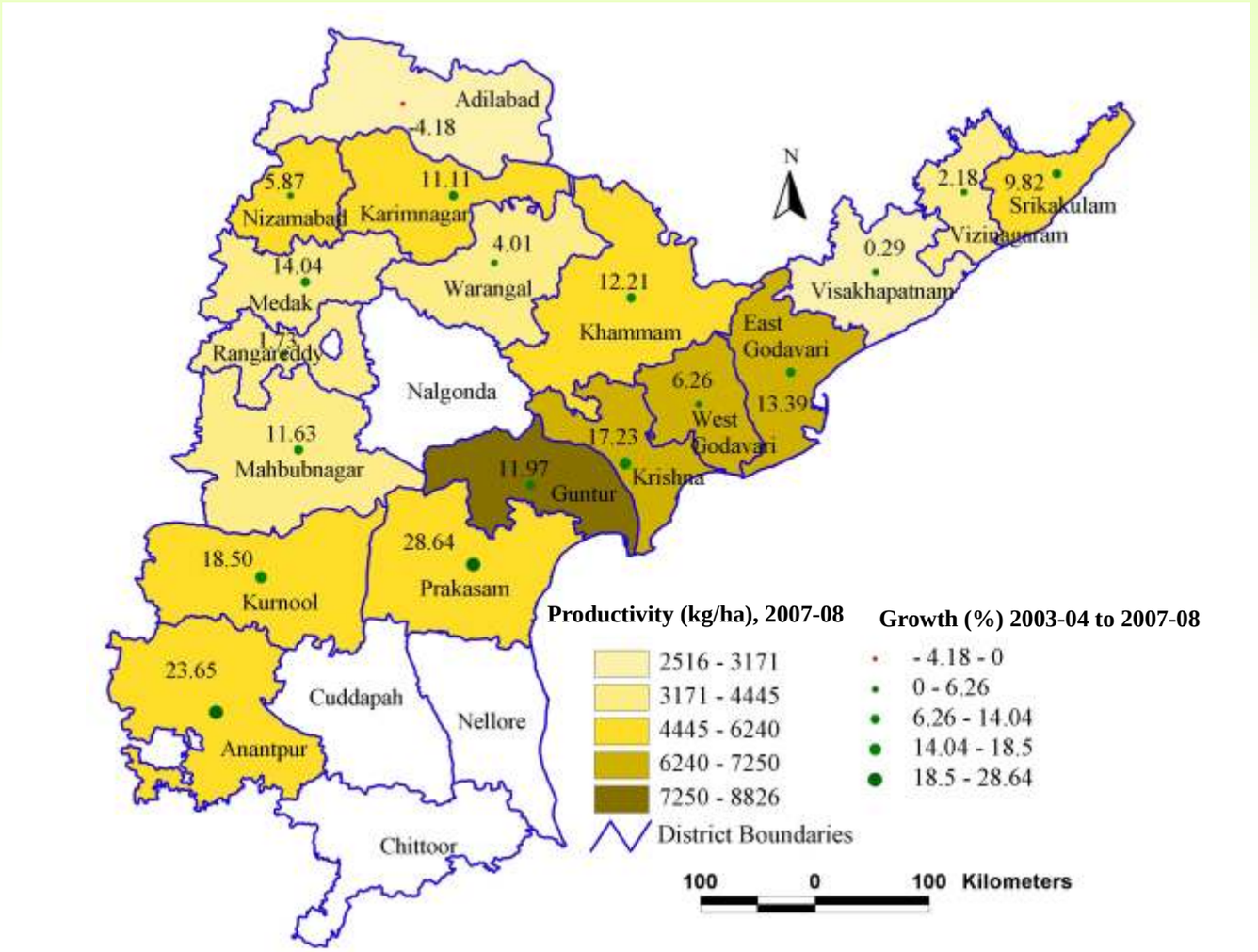
Godavari, Ananthpur and Krishna districts showed remarkably higher growth rate of maize acreage. Therefore, the maize acreage is increasing in non-traditional maize growing areas of the state particularly in winter season.

The district-wise mapping of maize production in the state (Map 2) showed that maximum production (2007-08) has been recorded in Karimnagar district mainly due to highest acreage. However, the production growth rate during 2003-04 to 2007-08 (Map 2) was maximum in Kurnool (64.81%), Ananthpur (39.13 %), Guntur (30.74%) and Krishna (23.69 %) districts. The negative growth rate in production of maize was recorded in Prakasam, Ranga Reddy, Adilabad and Visakhapatanam districts mainly due to negative growth rate of maize acreage in these districts (Map 1).

The productivity of maize in AP is higher under non-traditional maize growing zones (Krishna and Godavari zones). The highest productivity of maize has been recorded in Guntur district (7.2 to 8.8 t ha^{-1}) followed by Krishna, West and East Godavari being 6.2 to 7.2 t ha^{-1} which seems to be higher than the corn productivity of USA on per day basis. In general the maize productivity growth rate varied from -4 to 29 % (Map 3). Except Adilabad district, the productivity growth rate (2003-04 to 2007-08) of maize in the state has shown remarkable increase with maximum growth in Ananthpur despite its scarce rainfall zone.



Map 2 District-wise production (2007-08) & growth rate (2003-04 to 2007-08) of maize in Andhra Pradesh



Map 3 District-wise productivity (2007-08) & growth rate (2003-04 to 2007-08) of maize in Andhra Pradesh

Cultivar types and maize production in Andhra Pradesh:

The farmers of Andhra Pradesh are more advance in adoption of hybrid technology in maize compared to other states of the country. Most of the farmers are planting double cross hybrid seed of maize since past several years but recently, with the introduction of single cross hybrid technology and availability of single cross hybrids which are more productive and having better adaptability, the farmers of the state have switched over to single cross hybrids. Resultantly, nearly 70 % acreage of maize is covered under SCHs. Hence, the maize production in AP is directly correlated with the cultivar types and the recent revolution in corn production in the state is mainly governed by the adoption of single cross hybrids with high input use by the farmers. Moreover, as the productivity trends even in the risk prone areas has shown remarkably increasing trends that shows that the single cross hybrids have better adaptability even under the stress environments. Although significant genotype x tillage x environment interactions has been observed in maize, but single cross hybrids (SCH) has shown better adaptability to new set of cropping systems and management practices including tillage and new environments. Comparative studies on performance of hybrids (both single cross and double cross) under front line demonstrations (FLDs) under ISOPOM in coastal region of the state revealed that there was no perceptible difference in the yield of 3 SCHs, however, the yield of DCH was little inferior (Figure 3). Further, the higher yields were recorded with 60 x 20 cm plant density compared to 75 x 20 cm and high density responds to high rate of nitrogen application (Figure 4). But, there is need to optimize the plant density keeping in view of the plant type of the hybrid as it is not advisable to go for very high plant density that increases the cost of seed and also between plant competition.

Photo 3. Performance of SCH under zero tillage

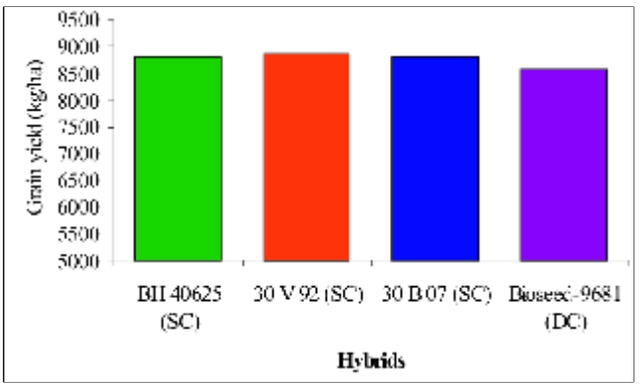


Figure 3 Performance of different hybrids during winter 2007-08 under FLDs (N = 05)

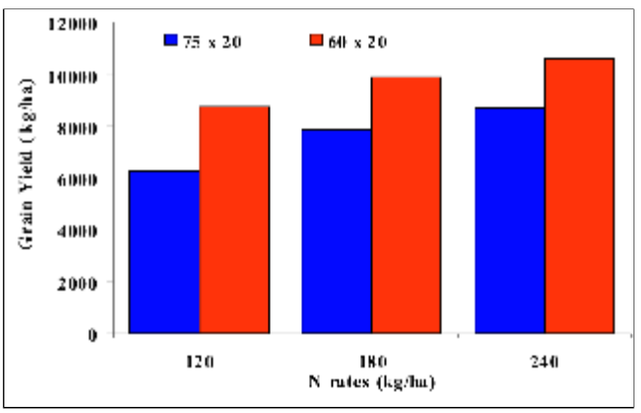


Figure 4 Interactive effects of plant geometry and nitrogen rates on grain yield of maize at ARS Madhira, AP during winter 2007-08 (Sreelatha, Personal Communication)

Cropping systems of Andhra Pradesh:

The Andhra Pradesh is a state of large diversity soil and climatic conditions that leads to diversified farming systems. The major cropping system of the state is rice based rotations followed by sorghum, groundnut, cotton, sugarcane and maize systems (Table 2). Maize systems are dominant in Telangana zones during monsoon season whereas during winter season, maize systems are mainly practiced in Krishna and Godavari zones in rice fallows.

Evolution of rice-maize system in Andhra Pradesh

In coastal peninsular India, rice-rice rotation is dominant system but, during recent years, double cropping of rice is becoming difficult due to shortage of irrigation water particularly during winters. Under such situations, possibilities for alternative potential crops having economical competence and that can be taken under water scarcity situations have been explored by the researchers and farmers as well. As an alternative, rice-pulses systems were tried by the farmers in the coastal districts of AP (Krishna, Guntur, Godavari) but due to lower productivity of pulses in rice fallow due to delayed sowings, weed, pests and disease problems, the rice-

Photo 4. Visit of Govt. officials to no-till maize fields at Tenali, A.P.

Table 2 Major cropping systems in different agro-climatic zones of AP

S No	Agro-climatic zone	Major cropping systems
1	North Coastal zone	Rice-rice, Rice-groundnut, Rice-sesame, Sugarcane, Mesta-rice, Ragi-rice
2	Godavari Zone	Rice-rice, rice-maize. Sugarcane, Tobbaco
3	Krishna zone	Rice-rice, Rice-maize, Rice-black gram, Rice-sesame, Cotton, Sugarcane, Chillies
4	Southern zone	Rice-rice, Rice-ragi, Rice-groundnut, Groundnut+redgram, Groundnut-groundnut, Groundnut+pulses
5	Northern Telangana zone	Rice-rice, Rice-groundnut, Rice-groundnut, Groundnut-groundnut, Groundnut+pulses, Cotton-maize
6	Central Telangana zone	Rice-rice, Rice- maize, Sorghum+red gram, Sorghum+bajra, Castor+red gram, Groundnut, Cotton
7	Southern Telangana zone	Rice-rice, Sorghum+redgram, Sorghum+castor, Sorghum+bajra, Rice-maize
8	Scarce rainfall zone	Rice-fallow, Groundnut+red gram, Sorghum+red gram, Sorghum+groundnut
9	High altitude tribal zone	Mostly podu cultivation

pulses system could not sustain. Therefore, possibility of maize in this non-traditional maize growing region was explored that has shown promise. Results of an experiment conducted for 4-consecutive years during 2004-05 to 2007-08 at Hyderabad under AICRP on CS (Sreelatha, Personal Communication) for comparing the productivity of different cropping systems showed that the average productivity of Kharif rice was higher under rice-maize system compared to rice-rice system (Figure 5). Further, the total system productivity of rice-maize was also higher compared to rice-rice cropping systems. This indicates that with rice-maize cropping system, higher productivity can be achieved with less quantity of irrigation water as the water requirement of maize is remarkably less than rice. Due to higher productivity and profitability and assured alternative winter crop after rice, the acreage of maize in coastal AP has shown an increasing trend and the rice-maize has emerged as a potential cropping system in coastal region of AP that covered nearly 0.25 million hectares of coastal Andhra Pradesh mainly concentrated in Guntur (more than 50 %), Krishna, west and east Godavari and few pockets in Telangana (AP state Deptt. of Agriculture, Guntur).

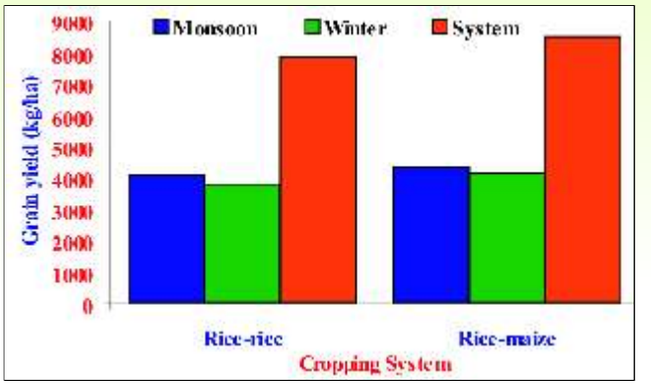


Figure 5. Comparative productivity of rice-rice and rice-maize systems in Telangana region of Andhra Pradesh

Zero till maize under rice-maize cropping systems

Under the emerging and potential crop sequence (rice-maize) in coastal region of Andhra Pradesh, the conventional tillage for planting maize under heavy textured soil of rice ecologies needs 25-

Photo 5. Farmer-Scientist interaction on establishment of Zero in maize.

Photo 6. Farmer's practice of no-till planting

30 % higher energy for field preparation that not only limits the farm profitability but also delays the planting of maize which in turn leads to lower productivity. The rice-maize cropping systems has emerged as potential cropping systems in Guntur, Krishna and west Godavari districts of AP, where the soils are heavy black with very high moisture

Photo 7. Manual drawn star wheel multi crop no-till planter.

retention capacity. Farmers of these districts grow maize on residual moisture after harvest of Kharif rice. Generally rice is harvested during 2nd fortnight of November. In case of zero tillage under rice-maize rotation, the farmers can plant maize in time but if maize is planted after repeated conventional tillage, the planting get delayed as for plouging, farmers have to wait for optimum soil moisture. Therefore, the maize yield under conventional tillage was recorded less compared to zero tillage under Front Line Demonstrations (FLDs) in these districts (Figure 6). Further, the no-till maize in rice fallow also demonstrated a potential benefit of saving on cost of production ranging from Rs 3800 to 5500 ha^{-1}.

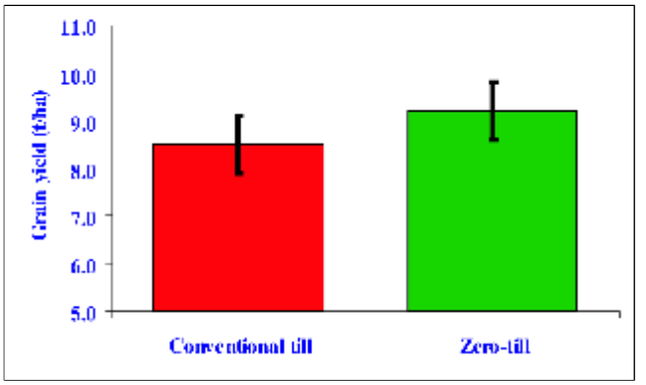


Figure 6. Comparative grain yield of maize under conventional and zero tillage in FLDs (N = 19) in coastal Andhra Pradesh

Weed management in zero till maize under rice-maize system:

The farmers generally go for dibbling of maize on residual moisture after harvest of rice without any preparatory tillage (Photo 6). Where in many times weeds becomes a sesions problem (Photo 9) Pre-plant application of paraquat (1.0 kg a.i. ha^{-1}) followed by pre-emergence application of atrazine (1.0 kg a.i. ha^{-1}) is being followed for weed control under no-till conditions and has been found effective strategy for weed management under this system (Photo 10). Results of a 2-year study carried out at ANGRAU, Hyderabad revealed that no-till maize in row geometry with pre-plant application of paraquat @1.0 kg a.i ha^{-1} + pre-emergence application of Atrazine @1.0 kg a.i. ha^{-1} resulted in significantly higher yield of maize being 8.1 and 8.4 t ha^{-1} respectively, during 2006-07 and 2007-08 which was nearly 21 % higher compared to farmers' practice of maize in rice fallow.

Photo 8. Comparative performance of maize after rice under conventiona land zero tillage

Photo 9. Weed problem in zero tillage without herbicide application

Photo 10. Weed control in no-till maize

Adoption of zero-tillage technology under maize in Andhra Pradesh:

To accelerate the adoption of this technology, efforts has been made through front line demonstrations (FLDs), field days and visits by the scientists from national agricultural research system (NARS), Officers of state Department of Agriculture of AP, Non Govt organizations, private sector, international organizations and the innovative farmers (Photo 11,12,13). Resultantly, inspite of recent introduction of zero till planting of maize in rice fallows in the state, the acreage under ZT increased from few acres during 2003-04 to nearly 0.2 million hectares during 2008-09 (Figure 7) of which more than 0.1 million hectares is concentrated in Guntur district alone followed by Krishna and west Godavari districts. Due to this technology, its not only that the acreage under zero-till is increasing every year but the acreage under maize is also increasing in this region. Therefore, the findings of the studies carried out at research stations as well as FLDs at farm level indicated that no-till technology with integrated crop management practices has a vast potential for diversification of winter rice under double cropping of rice in water scarcity areas of peninsular India wherein this technology can improve resource use efficiency and farm profitability.

Photo 11. Farmer-Scientist interaction on zero tillage

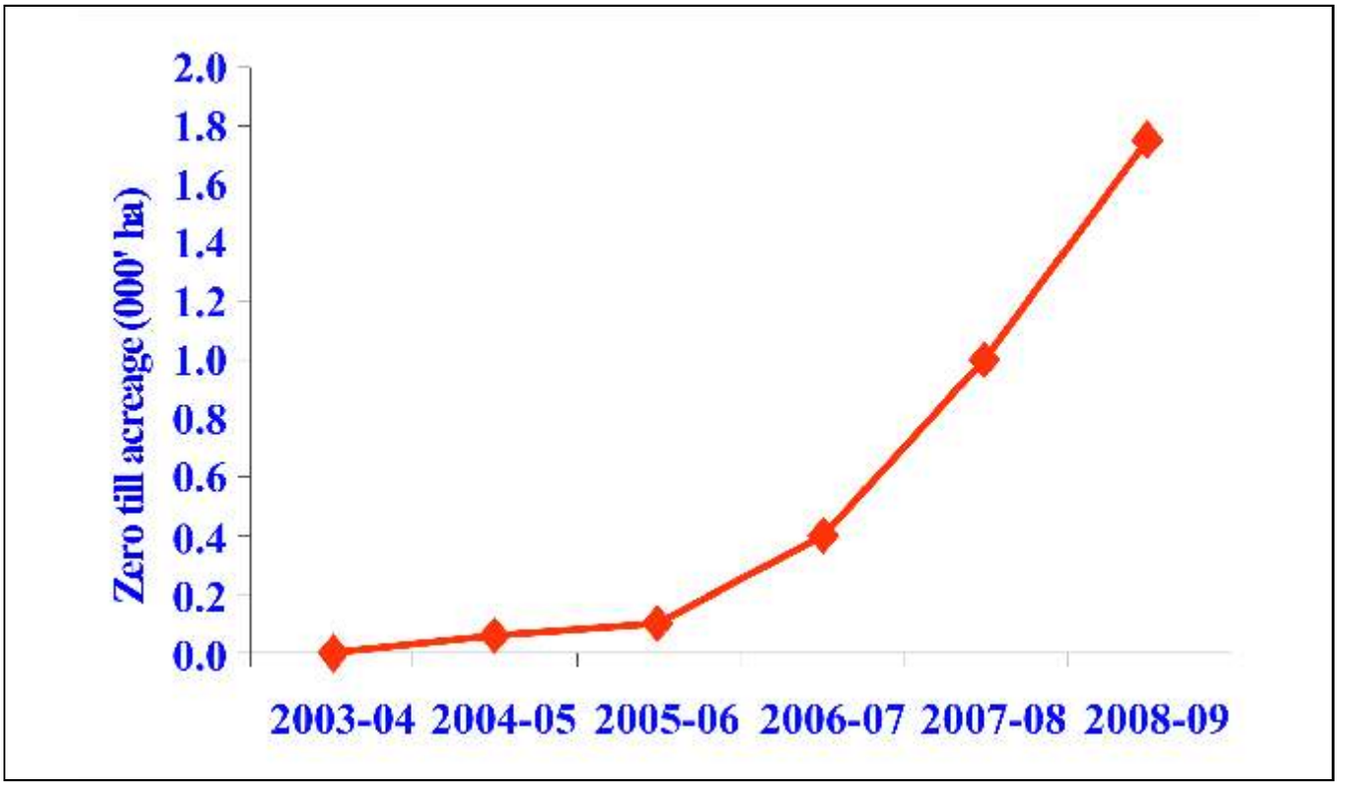


Figure 7. Adoption of zero-tillage technology in maize under rice-maize cropping systems of Andhra Pradesh

Photo 12. Field day on zero till maize under I SOPOM

Photo 13. Field day on zero till maize at Tenali

Farmer-led innovations for no-till planting:

As usual, the farmers are very innovative and develops technologies using their Indigenous Technical Knowledge (ITK). As the no-till dibbling of maize under rice-maize system becomes successful and profitable technology, an innovative farmer Sri. Jetty Sambasiva Rao of Tenali division of Guntur district invented a simple but very innovative dibbler for planting maize under no-till. This is a single wheel marker designed using bi-cycle wheel (Photo 14). This dibbler makes holes at a spacing of 20 cm. As experienced by the farmers of the region, using this dibbler, 10-12 labour can plant the maize in one hectare under no-till and the total cost of planting comes to be nearly Rs 1500 ha^{-1}. Using this technique, a net saving of 4-6 man days ha^{-1} can be achieved over manual dibbling of maize under no-till which is widely practiced by the farmers of the region.

Photo 14. Innovative wheel dibbler developed by farmer

Photo 15. A Farmer standing with bumper maize crop under zero tillage

Future actions required

The maize particularly during winter season becoming a potential alternative crop to winter rice in Andhra Pradesh. Two technologies i.e. Single Cross Hybrids and Zero-Tillage are becoming very popular in maize systems of the state. Further strengthening of these technologies for farmers profitability and long-term sustainability, the following actions / interventions are to be initiated-

- The seed replacement rate in maize in AP is very high and almost all the farmers are taking hybrids of corn in the state. However, the seed is costly due to lack of seed production chain of the public bred single cross hybrids. Therefore, there is a need to strengthen the seed production of public bred hybrids through 'Public-Private Partnership' so that the availability of SCH seed can be ensured in time and at less cost.
- The 'No-till' planting of maize is well accepted technology particularly under rice-maize systems of coastal Andhra Pradesh. However, till now, manual dibbling is being practiced due to non-availability of No-till planters in the region. Therefore, there is a need to strengthen the local manufacturing units for the no-till planters that suits the local requirements.
- Massive efforts on training of the local artisans, tractor operators and farmers are essentially needed for realizing better productivity & farm profitability and to accelerate the adoption of the technology in larger domain.
- Identifying the compatible genotypes that gives higher yields under 'No-Till' conditions. Therefore, the tillage x genotype interaction studies needs to be carried out.
- Most of the farmers of irrigated intensive cropping region i.e. rice-maize cropping systems of the coastal AP are growing maize with high plant density i.e. 80000 to 100000 plants ha^{-1} with inappropriate and imbalance nutrient application (390 kg N, 115 kg P_2O_5, 75 kg K_2O) that needs to be optimized for profitability and long-term system sustainability.
- Developing agro-techniques i.e. nutrient, weed, water and pest management, for emerging cropping systems like rice-maize wherein the existing management practices may not work due to varied edaphic requirement for either of the crops in sequence.

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