On-farm evaluation of performance of soybean-maize sequence vis-a-vis maize-maize cropping system under medium black soils of Telangana

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Abstract
Crop diversification with resource efficient and remunerative cropping systems is a sustainable agricultural practice. On farm evaluation with diversified cropping system of soybean-maize vis-a-vis farmers’ practice of maize-maize was conducted in ten farmer’s fields of Warangal district of Telangana state. Crop diversification with soybean-maize realized 7% higher mean maize grain yield equivalent yield (12302 kg ha⁻¹) over farmer’s practice of cultivation of maize-maize (11492 kg ha⁻¹) with a mean gain of 810 kg ha⁻¹. Mean technology and extension gaps were 698 kg ha⁻¹ and 810 kg ha⁻¹ respectively. Technology index ranged from 0.7 to 12.4% with an average value of 5.4%. The mean gross and net returns of diversified cropping system were Rs.141471 and 68941 ha⁻¹, while that of farmers practice were Rs 132158 and 55693 ha⁻¹ respectively. On an average a B C ratio of 2.0 was earned in improved cropping system as against the 1.7 under farmers practice. The mean additional returns in improved cropping system were Rs 9313 ha⁻¹ with a mean effective gain of Rs 13249 ha⁻¹. Improved cropping systems registered a mean total productivity per day of 33.7 kg ha⁻¹ day⁻¹ with a mean profitability of Rs 189 day⁻¹. Average Production Use Efficiency of improved cropping system was 61.5 kg ha⁻¹ day⁻¹, while that of farmer’s practice was 57.5 kg ha⁻¹ day⁻¹. The edge in productive economic parameters in terms of Mean Relative Productive Use Efficiency and Relative Economic Efficiency were 7.0 and 23.8 respectively and were indicating the profitability of diversified cropping system.

Keywords: Crop diversification, soybean-maize, maize-maize, maize equivalent yield, technology gap, technology index, production efficiency, economic efficiency

Introduction
Maize is the one of the principal crops in Telangana state grown in 5.73 lakh ha with a production of 17.51 lakh tonnes and productivity of 3057 kg ha⁻¹ (Telangana Directorate of Economics and Statistics, 2017) [25]. Warangal is one of the maize growing districts of the state, with 0.75 lakh hectares of area. The crop is grown on diverse kinds of soils varying from medium black soils to light red soils. Majority of the crop in the state is grown as rainfed under low fertile soils while under irrigated situations, two crops of maize are grown in sequence per year. Maize being an exhaustive crop, mono-cropping of the crop threatens the soil sustainability. Further due to resurgence of pests and diseases particularly the post flowering stalk rots drastic losses yield were common. Under such circumstances, diversifying cropping systems by increasing the spatial and temporal heterogeneity of agricultural mosaics might be a feasible alternative to overcome the negative effects of modern agriculture (Burel et al., 2013) [3]. Further, ignoring of pulses in cropping pattern and dwindling of cattle population is leading to exhaustion of soil organic matter making the soil ecosystem more fragile with low moisture retentivity and poor fertility. Unfortunately legume incorporation in the soil has been slowly eliminated from cropping systems, and has led to serious consequences on soil fertility. Despite their great potential for making significant N contributions and improving productivity, the adoption of legumes is poor due to wide range of socio economic and physical constraints (Shah et al., 2003; Chikowo et al., 2006; Ojiam et al., 2006) [23, 6, 10]. Cultivation of legumes for seed, fodder or green manure can positively influence the structure and functioning of the agro-ecosystem (Pierce and Rice, 1988) [18]. Studies have shown that crop yield and product quality are usually improved when legume are grown as a preceding crop (Campiglia et al., 1999) [4] in any cropping sequence. Crop rotation with legumes improves soil properties (Bagayoko et al., 2000; Chan, and Heenan, 1996; Giller, 2001; Yusuf, et al., 2009) [1, 5, 8, 25]. And might therefore reduce mineral fertilizer requirements of succeeding non leguminous crops. Crop rotation also influences N use efficiency and prompt changes in various N sources, affecting availability to the plant
(Lopez and Lopez, 2001.) Legumes are known to increase soil N levels (National Academy of Science, 1979; Ladd et al., 1981; Reddy et al., 1986) Consequently they improve the productivity of subsequent cereal crops (Singh and Awasthi 1978) (20). Though legume materials contribute only a small portion of the available N pool, their main value appears to be long term, i.e., in their capacity to maintain or increase concentrations of soil organic N to be decomposed at relatively slow rates in the following years (Ladd et al. 1981) (11). Canavalia ensiformis, Mucuna pruriens, Glycine max, and Vigna unguiculata have been reported to potentially contribute considerable amounts of N to succeeding crops (Sangina, et al., 1996; Ravuri and Hume 1992; Mughogho, et al., 1982) (22, 14, 19). Soybean (Glycine max L.) is a dual purpose most important rainy season crop to meet pulse and oil requirements. It is also highly adaptable to varying soil and climatic conditions, giving fairly high yields compared to other pulse crops (Padhi and Panigrahi, 2006) (137). Soybean being a short duration (85 to 130 days depending on the latitude) leguminous energy rich crop, offers good potential to get involved in the cropping sequences or intercropping systems. The crop is relatively tolerant to drought, excessive moisture, low pH and high aluminum content (Billore, 2014) (2). Further its cultivation does not cause any allelopathic effect on companion/succeeding crops, extends benefits of 45 to 60 kg residual nitrogen per hectare to the succeeding crop and creates salutary physio-chemical environment in the soil for crop growth (Kumar et al., 2012) (10). Soybean due to its trade and industrial significance and adaptability to varied agro-climatic conditions occupies greater part of potential cultivated area as an integral part of prevailing cropping systems in India and world over. In Telangana state, at present soybean is cultivated over 0.24 million hectares with an annual production of 0.25 million tones and productivity of 1036 kg ha⁻¹ (Telangana Directorate of Economics and Statistics, 2017) (25). However, productivity of soybean can further be increased by including in the cropping sequences as intercrop or as sequence crop. Area under soybean is increasing enormously in Northern parts of Telangana state due to better yield potential and market price. Keeping in view the above, soybean-maize sequence is evolved as an alternative sustainable and climate smart cropping system to maize-maize in medium black soils.

Materials and Methods
To study and demonstrate the production potential of improved cropping system of soybean followed by maize in comparison with farmer’s practice of maize-maize, front line demonstrations were conducted during the year 2016-17 in 10 locations (irrigated and medium back soils) of Warangal district by On Farm Research Centre, All India Coordinate Research Project on Integrated Farming Systems. An area of 0.4 ha per each location was chosen for study. The variety JS-335 of soybean and popular private hybrids for maize were used in the study. JS 335 variety of soybean has yield potential of 20-25 q ha⁻¹ and comes to maturity in 90-95 days. Private hybrids of maize with 90 days duration and yield potential of 60-70 q ha⁻¹ were selected. Cultivation of maize-maize (farmer’s practice) was considered as control. Sowing of crops in both the treatments during kharif season were done during June 3rd week to 10th July 2017. Whereas Rabi crops soybean and maize were sown during October 2nd week to November 1st week. Recommended spacing was adopted for soybean (45 X 5 cm) and maize (60 X 20 cm). A seed rate of 70 kg ha⁻¹ and 8 kg ha⁻¹ was adopted for soybean and maize respectively. Seed treatment with thiram @ 3 g /kg of seed followed by 5ml of imidacloprid /kg of seed to prevent pest and diseases. All management practices for weed, nutrient, pest and diseases were adopted as per the recommendations of PJTSAU. A rainfall of 990 mm was received in 65 rainy days and the crop was maintained rainfed during kharif season and 6 numbers of irrigations provided during Rabi season. The data on grain yield was collected by random crop cutting method and the yield of both the crops was presented as maize grain equivalent yield. It was calculated by converting the seed yield of soybean into maize equivalent yield on the basis of sale price of soybean.

**Maize Equivalent Yield=**

(Soybean grain yield (kg ha⁻¹) x Price of soybean (Rs kg⁻¹)

Maize grain price (Rs/kg)

**Paired T test** was employed to test the efficiency of improved cropping system over farmers practice. Benefit Cost ratio, gross and net returns were calculated based on grain yield and prevailing market price. Per day net returns were worked out by dividing total net returns with the duration of the crop. The extension gap, technology gap and technology index were calculated as per the following formula drawn by Samui et al. (2000).

Extension gap= Yield of Improved practice - Yield of farmers practice

Technology gap= Potential yield – yield of improved practice

**Technology index=**

\[
\text{Technology index} = \frac{\text{Technology gap}}{\text{Potential yield}} \times 100
\]

Production and Economic indices are calculated based on following formulae.

**Additional Returns= Extension gap X Sale price**

**Effective gain = Additional returns – Additional cost**

**Returns per rupee investment (Rs Re⁻¹) = Net Returns/Cost of Cultivation**

**Per day Productivity (kg ha⁻¹ day⁻¹) = Total productivity/365**

**Per day Profitability (Rs ha⁻¹ day⁻¹) = Total profitability/365**

Production Use Efficiency is efficiency measured in terms of yield/day

**Production Use Efficiency (kg ha⁻¹ day⁻¹) =**

Total grain yield of a system

**Period in days consumed to produce the yield**

**Relative Productive Use Efficiency (%)**

\[
\text{Relative Productive Use Efficiency} (%) = \frac{\text{Total Productivity in diversified cropping system} - \text{Total productivity in existing cropping system}}{\text{Total productivity in existing cropping system}} \times 100
\]

**Relative Economic Efficiency (%)**

\[
\text{Relative Economic Efficiency} (%) = \frac{\text{Net Returns of diversified cropping system} - \text{Net Returns of existing cropping system}}{\text{Net Returns of existing cropping system}} \times 100
\]
Results and Discussion

Grain yield

The Maize Grain Equivalent Yield (MGEY) of diversified cropping system of soybean - maize was ranging from 11394 kg ha\(^{-1}\) to 12914 kg ha\(^{-1}\) across the locations and was 4.6 to 7.4% higher than of maize-maize system (farmers’ practice) yields (10885 kg ha\(^{-1}\) to 12015 kg ha\(^{-1}\)). Mean MGEY of improved cropping system (Table 1) of soybean - maize was 7% higher (12302 kg ha\(^{-1}\)) than grain yield in farmers practice of maize-maize system (11492 kg ha\(^{-1}\)). The mean gain of maize grain equivalent yield was significantly greater than zero (Mean =810, SD =444, N= 10) with a t-stat value of 5.77and two-tail p value of 0.000269, providing evidence that the improved cropping system is efficient than farmers practice. Legumes are noteworthy for their nitrogen fixation, particularly soybeans have symbiotic nitrogen-fixing bacteria in root nodules. The crop fixes atmospheric nitrogen in soil. Thus preceding soybean in soybean-maize system might have sustained the organic matter content through litter fall and leaf biomass and thereby enhanced the biological activity in turn soil fertility and nutrient availability to succeeding maize and resulting in increased yield of maize in soybean-maize system than maize-maize system. Munyinda et al. (1988) \(^9\) also reported higher wheat grain yield in soybean-wheat system than other systems like maize-wheat. Reddy et al. (1986) \(^20\) and Singh and Awasthi (1978) \(^24\) also reported similar results for rye, maize and wheat, which produced higher yields following tropical legumes than cereals.

Economics

Diversified cropping system of soybean - maize earned gross returns ranging from Rs. 1, 31, 030 to Rs 1, 48, 510/- across the locations. While gross returns of maize-maize under farmers practice ranged from Rs. 1, 25, 177 to Rs 1, 38, 173/- (Table 2). The mean gross returns under improved cropping systems were Rs 1, 41, 471 vis-a-vis Rs 1, 31, 158/- in farmers’ practice. The mean gain of net return was Rs 9,313 with standard deviation of 5104 and was significant over farmers practice. Net returns in improved cropping systems ranged from Rs.60,330 to Rs.77, 960 with mean value of Rs 68, 941 while net returns of farmers practice of maize-maize system varied from Rs 51, 028 to Rs 62, 573 with an average net returns of Rs 55, 693/-. The returns on earned per rupee investment were ranging from Rs 1.8 to Rs 2.1 with mean BC ratio of Rs 2.0 in improved cropping system, whereas in farmers practice the benefit was Rs 1.7-1.8 per rupee cost with mean value of 1.7. Per day returns ranged from Rs. 302 to Rs.390 in improved cropping system with as an average of Rs 345. While maize-maize system resulted in Rs 255 to 313 per day returns with mean of Rs 278. Higher economics in improved cropping systems over farmers’ practice can be attributed to higher Maize grain equivalent yield, high gross and net returns and lower cost of cultivation. These findings are also in agreement with the results of Malik et al. (1991) \(^13\) who reported residual effect of legumes such as pigeonpea, mungbean and cowpea on cereals (maize and wheat) and found increasing monetary returns. Gadgil et al. (2002) \(^7\) reported that high benefit cost ratio and effective net returns can be obtained with the introduction of legume based cropping patterns.

Technology gap, Extension gap and Technology Index

Technology gap ranged from 86 kg ha\(^{-1}\) to 1867 kg ha\(^{-1}\) with a mean of 698 kg ha\(^{-1}\). Whereas extension gap varied from 194 to 1508 kg ha\(^{-1}\)with average value of 810 kg ha\(^{-1}\) (Table 1). Technology index represents the feasible adaptability improved cropping systems from lab to land. Lower the technology index means more viability of innovative cropping system at farmer’s field. Thus attaining higher yields almost close to potential yields will hasten up the adoption of improved cropping system interventions to increase the yield performance. The technology index in the current study ranged from 0.7 to 12.4% with an average value of 5.2%.

Production and economy indices

Additional returns in diversified cropping system ranged from Rs. 2230 to 17340 ha\(^{-1}\) with mean additional returns of Rs 9313 ha\(^{-1}\) (Table 3). Effective gain in improved cropping system ranged from Rs 6930 ha\(^{-1}\) to Rs 21640 ha\(^{-1}\) with an of Rs 13249 ha\(^{-1}\). Total per day productivity in improved cropping systems varied from 31.2 kg to 35.4 kg ha\(^{-1}\) day\(^{-1}\) with mean of 33.7 kg ha\(^{-1}\) day\(^{-1}\) as against 31.8 kg ha\(^{-1}\) day\(^{-1}\) in farmers practice which ranged from 29.8 to 32.9 kg ha\(^{-1}\) day\(^{-1}\). Mean per day profitability of diversified cropping system was Rs 189 and was ranging from Rs 165 to Rs 214/-.

Production Use Efficiency of diversified soybean-maize system ranged from 57.0 to 64.6 kg ha\(^{-1}\) day\(^{-1}\) with an average of 61.5 kg ha\(^{-1}\) day\(^{-1}\), while it was 54.4 to 60.1 kg ha\(^{-1}\) day\(^{-1}\) with mean of 57.5 in maize-maize system. Relative Productive Use Efficiency of soybean-maize system shoot up to 13.4% with an average of 7.0% whereas Mean Relative Economic Efficiency was 23.8% and it ranged from 11.5 to 40.7%.

<table>
<thead>
<tr>
<th>Trial No</th>
<th>Grain yield (kg ha(^{-1})) in Improved (soybean-maize) cropping systems</th>
<th>Maize Equivalent Yield (kg ha(^{-1}) in Improved system)</th>
<th>Maize yield in farmers practice (maize-maize) (kg ha(^{-1}))</th>
<th>Maize Gain Equivalent Yield (kg ha(^{-1})</th>
<th>Potential yield of Improved system (kg ha(^{-1}))</th>
<th>% increase in yield over farmers practice</th>
<th>Technology gap (kg ha(^{-1}))</th>
<th>Extension gap (kg ha(^{-1}))</th>
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\(^*\) Std. Dev. \(^*\) t statistic \(^*\) Two-tail p-value = 0.000269

Table 1: Grain yield, Technology gap, Extension gap and Technology Index of improved cropping system vis-a-vis farmers’ practice

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Table 2: Economics of improved cropping system Vis-à-Vis farmers’ practice.

<table>
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<th>Trial No</th>
<th>Cost of Cultivation (Rs ha⁻¹)</th>
<th>Gross Returns (Rs ha⁻¹)</th>
<th>Net Returns (Rs ha⁻¹)</th>
<th>B: C ratio</th>
<th>Per day Net Returns (Rs ha⁻¹)</th>
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Mean 72530 | 76466 | 141471 | 132158 | 9313 | 68941 | 55693 | 2.0 | 1.7 | 345 | 278 |

Std dev 5104

Table 3: Production and Economic indices of improved cropping system Vis-à-Vis farmers’ practice.

<table>
<thead>
<tr>
<th>Trial No</th>
<th>Addition Returns (Rs ha⁻¹)</th>
<th>Effective gain (Rs ha⁻¹)</th>
<th>Per day productivity (kg ha⁻¹ day⁻¹)</th>
<th>Per day Profitability (Rs ha⁻¹ day⁻¹)</th>
<th>Production Use Efficiency (kg ha⁻¹ day⁻¹)</th>
<th>Efficient Use Efficiency (%)</th>
<th>Relative Productive Use Efficiency (%)</th>
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Mean 9313 | 13249 | 33.7 | 31.5 | 189 | 61.5 | 57.5 | 7.0 | 23.8 |

Conclusion
Results obtained from computation of indices, yield and returns showed a significant advantage of diversifying the system with soybean – maize sequence crop rather than mono-cropping of maize-maize system in medium black soils of Telangana state.

References


