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Growth and Yield of Maize Crop under different Conservation Practices in Semi Arid Region of India

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Abstract—*With the increasing global population and degrading natural resources, enhancement of the food production on sustainable basis is the need of the hour. This can be achieved by number of ways. Adoption of conservation agriculture is one of the important options for that. Field study was conducted on maize crop under different conservation agricultural practices during the kharif season, 2014 at the research farm of ICAR-Indian Agricultural research Institute, New Delhi. Maize crop was sown under different conservation practices such as conventional tillage (CT), zero tillage narrow bed (ZT NB), zero tillage narrow bed plus residue (ZT NB+ R), zero tillage broad bed(ZT BB), zero tillage broad bed plus residue (ZT BB+R), zero tillage flat bed (ZT FB), zero tillage flat bed plus residue (ZT FB+R). Observations on different crop growth parameters such as leaf area, biomass, partition of biomass and yield were measured at different growth stages. Result shows that zero tillage broad bed plus residue (ZT BB+R) treatment had higher value of biomass, leaf area and yield followed by zero tillage broad bed (ZT BB), zero tillage flat bed plus residue (ZT FB+R), zero tillage flat bed (ZT FB), zero tillage narrow bed plus residue (ZT NB+ R), zero tillage narrow bed (ZT NB), conventional tillage (CT) system. Conservation practices modifies the soil physical environment and may be due the better soil physical environment, zero tillage broad bed plus residue treatment as well as other conservation practices had better growth and yield as compared to the corresponding value in the conventional tillage.*

Keywords*: Maize, Conservation practices, Biomass, Leaf area, Yield*

1. INTRODUCTION

Agriculture is extremely vulnerable to climate change. Changes in precipitation patterns increase the likelihood of short-run crop failures and long-run production declines (Fan *et al.*, 1998). Globally, atmosphere CO_2 concentration has increased by 31% during the past century and atmospheric O_3 has risen by 1% per year during the past four decades. Building climate resilience is crucial in India as the country is experiencing terminal heat stress, elevated O_3, high seasonal variation in rainfall and occurrence of extreme events. Modifications are required in agriculture to adapt with the changing climate and it is important to know its impact and vulnerability assessment and for the development of climate change policy (Smit *et al*., 2009). Conservation agriculture (CA) would adapt to the expected future climate change under different cropping pattern. Conservation agriculture is as an approach to farming that seeks to increase food security, alleviate poverty, conserve biodiversity and safeguard ecosystem services. Conservation agriculture practices can also contribute to making agricultural systems more resilient to climate change. In many cases, conservation agriculture has been proven to reduce farming systems' greenhouse gas emissions and enhance their role as carbon sinks. Conservation Agriculture is a powerful mechanism to adapt to climate change by increasing resilience to drought and increasing water-use efficiency. It is defined as minimal soil disturbance (no-till, NT) and permanent soil cover (mulch) combined with rotations, is a recent agricultural management system that is gaining popularity in many parts of the world.

Conservation agriculture (CA) promotes minimal disturbance of the soil by tillage (zero tillage), balanced application of chemical inputs (only as required for improved soil quality and healthy crop and animal production), and careful management of residues and wastes (Gupta *et al*., 2007). This reduces land and water pollution and soil erosion, reduces long-term dependency on external inputs, enhances environmental management, improves water quality and water use efficiency, and reduces emissions of greenhouse gases through lessened use of fossil fuels (Lumpkin and Sayre, 2009). ZT plus mulch reduces surface soil crusting, increases water infiltration, reduces run-off and gives higher yield than tilled soils (Cassel *et al.*, 1995). Similarly, the surface residue, anchored or loose, protects the soil from wind erosion (Michels *et al.*, 1995). The dust bowl is a useful reminder of the impacts of wind and water erosion when soils are left bare. Retention of crop residue on the soil surface in combination with no-tillage initiates processes that lead to improved soil quality and overall enhancement of resource use efficiency (Ghosh *et al*., 2010).

Use of raised bed- furrow irrigated seeding system in northwest India resulted in both higher yields and significant irrigation water savings for a wide spectrum of crops, when compared to the traditional farmer practice of seeding on the flat with flood irrigation (Aggarwal & Goswami, 2003; Gupta *et al.,* 2007). Conservation agriculture practices i.e., no tillage and surface maintained crop residues set in processes which initiate changes in soil physical, chemical and biological properties which, in turn, affect root growth and crop yield. Understanding the dynamics of these changes and interactions between physical, chemical and biological phases is basic to develop improved soil, water and nutrients management strategies. A tillage system in conservation agriculture will include no tillage , minimum tillage or permanent bed planting system along with sufficient residue cover on surface or incorporated in the soil. Adoption of a suitable conservation tillage system and its long term effect on soil physical environment are the current research priorities. Keeping in view of above points a study was undertaken to understand the effect of different conservation practices on growth and yield of the maize crop.

2. MATERIALS AND METHODS

Field studies on maize crop were conducted under different conservation agricultural practices during *kharif* season, 2014 at the research farm of ICAR-Indian Agricultural research Institute, New Delhi located at 28^{o}35' N latitude, longitude of 77^{o}12' E and at an altitude of 228.16 m above mean sea level. The field had a fairly leveled topography. The climate of the research farm is semi-arid with dry hot summer and cold winters. May and June are the hottest months with mean daily maximum temperature varying from 40 to 46^o C, while January is the coldest month with mean daily minimum temperature ranging from 6 to 8^o C. The mean annual rainfall is 710 mm, of which 80% is received during southwest monsoon from July to September and the rest is received through ‘Western Disturbances’ from December to February. Air remains dry during most part of a year. The mean wind velocity varies from 3.5 km hr^{-1} during October to 4.3 km hr^{-1} in April. Pan evaporation varied between 3.5 to 13.5 mm d^{-1} and reference evapotranspiration from 9-15 mm d^{-1}. The soil of the experimental site belongs to the major group of the Indo-Gangetic alluvium. The soil texture is sandy clay loam (fine loamy, illitic, Typic Haplustept) with medium to weak angular blocky structure. The soil is non-calcareous and neutral in reaction.

The different treatments were conventional tillage (CT), zero tillage narrow bed (ZT NB), zero tillage narrow bed plus residue (ZT NB+ R), zero tillage broad bed(ZT BB), zero tillage broad bed plus residue (ZT BB+R) ,zero tillage flat bed (ZT FB), zero tillage flat bed plus residue (ZT FB+R). Observations on different crop growth parameters such as leaf area, biomass, partition of biomass and yield were recorded at different crop growth stages. Field measurements of leaf area were carried out in using LI 3100 area meter (LI- COR). Leaves were taken from each plant and put in the instrument. Reading should be taken carefully such that no two leaves should be overlap. Three leaf area readings were recorded in each treatment and average value were taken for leaf area. For measuring the biomass three plants were selected randomly in each plot and cut at ground level. Those plants were oven dried at 65°C for 48 hours or more and weighed by using electrical digital balance until a constant weight was achieved. Dry biomass produced was expressed in g m^{-2}. Seed yield were measured after harvest.

3. RESULT

3.1. Biomass

The biomass measured at different growth stages are shown in Fig.1. Maize biomass starts with an initially slow growth phase till the end of vegetative growth stage followed by a rapid growth phase like tassel stage initiation and continued till physiological maturity stage in all treatments. Highest biomass accumulated in zero tillage broad bed plus residue (ZT BB+R) followed by zero tillage broad bed(ZT BB), zero tillage flat bed plus residue (ZT FB+R), zero tillage flat bed (ZT FB), zero tillage narrow bed plus residue (ZT NB+ R), zero tillage narrow bed (ZT NB), conventional tillage (CT). The percentage increase in biomass as compare to conventional tillage (CT) was 10-15 % under zero tillage narrow bed (ZT NB), 28-40 % under zero tillage narrow bed plus residue(ZT NB+R), 30-43% under zero tillage flat bed (ZT FB), 36-47% under zero tillage flat bed plus residue (ZT FB+R), 53-57% under zero tillage broad bed (ZT BB) and 54-65% under zero tillage broad bed plus residue (ZT BB+R) (Fig. 1).

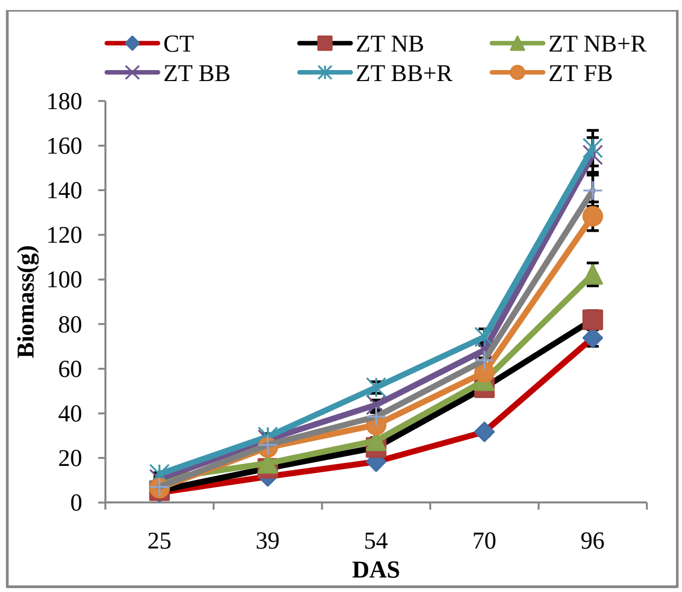

Fig. 1: Biomass at different growth stages under different conservation practices

3.2 Partition of Biomass

As plant grows, due to photosynthesis process biomass is form and transfer from source to sink or transfer to different plant parts like shoot, roots, cobs etc. which is necessary for growth and development, it called partition of biomass.

The partition of biomass in different plant parts at the time of maturity are shown in the table 1.

Table 1: Partition of biomass among different plant parts at the time of maturity under different conservation practices.

	SHOOT	LEAF	ROOT	cob	Biomass
T1	6.65± 0.48	12.99± 0.76	4.37± 0.52	49.78± 0.99	73.78± 0.53
T2	8.16± 0.13	13.53± 0.15	5.46± 0.44	54.79± 0.32	81.94± 0.28
T3	12.98± 0.53	15.78± 0.69	5.65± 0.29	67.89± 0.51	102.30± 1.10
T4	24.23± 0.23	28.58± 0.48	6.81± 1.33	95.45± 0.71	155.84± 0.68
T5	24.99± 0.41	29.57± 0.42	6.93± 0.45	98.17± 0.18	158.89± 0.61
T6	17.89± 0.69	19.67± 1.30	5.93± 0.80	84.88± 0.88	128.37± 2.14
T7	21.64± 0.36	20.54± 0.48	6.32± 0.21	91.34± 0.92	139.85± 0.81

3.3 Leaf Area

Different conservation treatment provide favourable conditions for crop growth resulting highest leaf area accumulated in zero tillage broad bed plus residue (ZT BB+R) followed by zero tillage broad bed (ZT BB), zero tillage flat bed plus residue (ZT FB+R), zero tillage flat bed (ZT FB), zero tillage narrow bed plus residue (ZT NB+ R), zero tillage narrow bed (ZT NB), conventional tillage (CT) (Fig. 2).

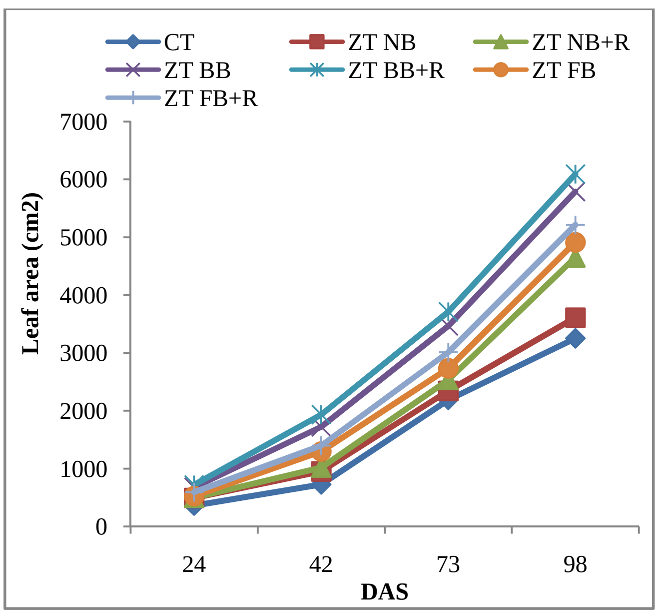

Fig. 2: Leaf Area at different growth stages under different conservation practices

The percentage increase in leaf area as compared to conventional tillage (CT) was 10-26 % under zero tillage narrow bed (ZT NB), 27-30 % under zero tillage narrow bed plus residue (ZT NB+R), 28-44% under zero tillage flat bed (ZT FB), 31-48 % under zero tillage flat bed plus residue (ZT FB+R), 44-57 % under zero tillage broad bed (ZT BB) and 50-62% under zero tillage broad bed plus residue (ZT BB+R).

3.4 Yield

The seed yield was found to be higher value under different conservation treatments as compared to corresponding value in the conventional tillage (Table. 2).

Table 2: Seed yield of maize under different conservation practices.

Treatment	Yield (t/ha)
CT	4.246± 0.325
ZT NB	4.524± 0.099
ZT NB+R	5.286± 0.070
ZT BB	5.733± 0.403
ZT BB+R	5.736± 0.061
ZT FB	5.598±0.065
ZT FB+R	5.705±0.202

Zero tillage broad bed plus residue (ZT BB+R) had maximum yield (5.736±0.061 t/ hac). It had 25.98% more yield as compared to conventional tillage treatment. Zero tillage flat bed (ZT BB) had 25.94%, zero tillage flat bed plus residue (ZT BB+R) had 25.57%, zero tillage flat bed (ZT BB) had 24.15%, zero tillage narrow bed plus residue (ZT NB+ R) had 19.67% and zero tillage narrow bed (ZT NB) had 6.14% more yield as compared to conventional tillage treatment.

4. CONCLUSION

From the study it was observed that for maize crop among all the conservation treatments zero tillage broad bed plus residue (ZT BB+R) was better than other treatments followed by zero tillage broad bed (ZT BB), zero tillage flat bed plus residue (ZT FB+R), zero tillage flat bed (ZT FB), zero tillage narrow bed plus residue (ZT NB+ R), zero tillage narrow bed (ZT NB), conventional tillage (CT) system. Conservation practices modifies the soil physical environment and may be due the better soil physical environment, zero tillage broad bed plus residue treatment as well as other conservation practices had better growth and yield as compared to the corresponding value in the conventional tillage.

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