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Impact of nitrogen management on physiological parameter of maize under conservation agriculture (*Zea mays* L.)

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Abstract
A field experiment was conducted at Experimental farm of ICAR-Indian Maize Research Institute, New Delhi during *kharif* seasons of two consecutive years (2016 and 2017) to study the physiological parameter of maize (*Zea mays* L.) under different cropping system, residue and nitrogen management. The treatments consisted two cropping system i.e Maize-wheat-mungbean-MWMu, Maize-mustard-mungbean – MmuMb, two residue management i.e. Permanent beds – without residue (PB-R), Permanent beds - with residue (PB+R) and four nitrogen management practices i.e. Absolute control - *No (fertilizer-*F_0), N through PU (Prilled urea) -F_1, N through SCU (S coated urea) -F_2, N through NCU (*Neem* coated urea)- F_3 in split – split- plot design with three replications. Maize variety DHM-117with 20 kg ha^{-1} seed rate was sown at spacing 67 cm x 20 cm during both the years. Results shows that dry matter accumulation (DMA) and leaf area index (LAI), MW Mb system gave higher value which was significantly higher than MM Mb cropping system. The SPAD value was lower in MMMu cropping system than MWMu. The permanent beds with residue incorpotaion significantly increased dry matter accumulation, leaf area index and SPAD value as compared to without residue application in both the years. The nitrogen management had significant effect on leaf area index in both the years. The Residue incorporation in permanent beds of maize yielded higher over without residue in permanent beds. It was noticed that the application of nitrogen by different sources increased compared with the control treatment. The nitrogen applied by Neem coated urea (NCU) recorded significantly higher NDVI, SPAD and minimum CTD value while absolute control recorded minimum NDVI and SPAD value.

Keywords: Residue, Sulphur coated urea, Neem coated urea, normalized difference vegetative index, canopy temperature depression, soil plant analysis development and permanent beds

Introduction
Maize *(Zea mays)* also known as back bone of America or "Queen of cereals" is the world's third most important cereal after wheat and rice and grown in different agro-ecological regions (AER). Worldwide maize is grown in an area of about 184.8 million hectares (m ha) with annual production of 1037.8 million tonnes (m t), with the productivity of 5.62 tonnes/ha (FAO STAT, 2014). About 34.7% of the maize is produced in the United State of America followed by China (21.4%), Brazil (7.8%), Mexico (2.2%), India (2.2%) and Indonesia (1.8%). The highest productivity of maize is in the Israel i.e. 22.56 tonnes/ha which is more than 4.1 times of the global average. In India, Maize an important crop for food, feed and nutritional security is grown in the production of 23.67 m t with an area of 9.25 m ha and an average productivity of 25.6 q/ha (Anonymous, (2019) [2]. India ranks 4th in maize area in the world but has the productivity less than half of the world's average. Maize grain is mainly used for feed (63%), food (23%) and industrial (13%) purposes in the country (Yadav *et al.*, 2015). As a grain crops and fodder and, it is extensively grown in Uttar Pradesh, Madhya Pradesh, Rajasthan, Karnataka and Bihar and now it is gaining popularity as a rice-maize cropping system by replacing the second rice crop in the existing rice-wheat or rice-rice-pulse cropping systems.
One hundred gram of Maize grain provides 361 calories of energy, 74.4 g carbohydrate, 9.4 g protein, 4.3 g fat, 290 mg phosphorus, 1.8 g fiber, 1.3 g ash, 10.6% water, 140 mg vitamins, 9 mg calcium and 2.5 mg iron and is a source of raw material for industry, where it is being extensively used for the preparation of corn oil, corn flakes, corn syrup, corn starch, cosmetics, dextrose, wax, tanning material and alcohol (Arain, 2013) [3].
The area under CA is increasing due to shortage of labour and escalating input prices in South Asian region and practiced on 157 m ha area worldwide (FAO, 2015) [6]. However, in India CA is practiced only on 1.5 m ha during 2013 (FAO, 2016) [7]. CA practices for crop production comprising of minimum soil mechanical manipulation, profitable crop rotation and permanent

soil cover found to be useful in reduction in cost of crop production in addition to giving ecological services for lower carbon emission/consumption and improvement in soil health. Conservation agriculture (CA) has emerged as a major way forwards from the existing unsustainable mode of crop production (Sharma and Behera, 2007). So, adoption of CA in India is required to harness more social and environmental benefits along with profitable sustainable farming and productive soils. Residue increases surface soil moisture and near the surface C source to microbes where high soil temperature favours denitrification which results in closer zone of denitrifying activity in soil. Despite more favourable results of CA in research, farmers are not adopting it at their field due to various reasons and one of them is improper nutrient especially N management practices. The crop residue retention on surface of soil under CA becomes hurdle of split-urea application and lowers the NUE as part of it either immobilized or volatilized due to fraction of applied fertilizer rest on the residue and consumed by the microbes. For enhancing profitability in maize system through CA there is need to increasing fertilize N-use efficiency through use of slow release fertilizer which will also act as problem solving for labour shortage in agriculture. Hence, proper management practices requires for enhancing NUE and reducing environmental foot print in CA system. So, the review suggests that there is need of proper N management practices for accelerating adoption of CA.

Materials and Methods

A field experiment was conducted at Experimental farm of ICAR-Indian Maize Research Institute, New Delhi during *kharif* seasons of two consecutive years (2016 and 2017) to study the growth and productivity of maize (*Zea mays* L.) under different cropping system, residue and nitrogen management. The Crop Research Center is located between latitude of site is situated at 28° 40'N latitude, 77° 11'E longitude and an altitude of about 228 m above mean sea level in New Delhi in a subtropical climate region. The annual maximum temperature goes up to as high 45 °C in summer whereas the minimum temperature dips to as low as -0.5 °C in winter seasons. The mean annual rainfall is about 650 mm, of which nearly 80 per cent is received during the monsoon period from July to September and the remaining during the period between October and May. The soil of the experimental field was loamy in texture alkaline in nature having pH (7.1), EC (0.22 dsm^{-1}), medium in organic carbon (0.425 and 0.433%), low in available nitrogen (206.0 kg ha^{-1}), medium in phosphorus (17.4 kg ha^{-1}) and potash (240 kg ha^{-1}). Maize variety DHM-117with 20 kg ha^{-1} seed rate was sown at spacing 67cm x 20 cm during both the years. The treatments consisted two cropping system i.e Maize-wheat-mungbean-MWMu, Maize-mustard-mungbean – MmuMb, two residue management i.e. Permanent beds – without residue – PB-R, Permanent beds – with residue (PB+R) and four nitrogen management practices i.e. Absolute control *No) (fertilizer-F* $_{0,}$ N through PU (Prilled urea)- $F_{1,}$ N through SCU (S coated urea)- $F_{2,}$ N through NCU (*Neem* coated urea)- F_3 in split – split- plot design with three replications. The mungbean crop residue including stem comprises of air dried leaf and branches of previous crop after picking the pods was kept in with residue plots in both the cropping systems while the mungbean plants were stalk cut and removed in without residue plots from the field. The recommended dose of nitrogen @ 150 kg/ha along with 60 kg P_2O_5 and 40 kg K_2O for Delhi region in hybrid maize was applied in all the treatments except absolute control. In prilled urea treatments, $1/3^{rd}$ dose of N and full dose of P_2O_5 and K_2O as basal were applied at the time of sowing by ferti-seed drill. In case of sulphur or neem coated urea (SCU & NCU) full dose of N along with phosphorus and potassium fertilizers recommended was drilled using ferti-seed drill at the time of sowing. Data on various physiological parameter such as leaf area index, crop growth rate, relative growth rate and SPAD were recorded as per the standard procedures. The experimental data were analysed statistically by applying the technique of analysis of variance (ANOVA) prescribed for the design to test and conclusions were drawn at 5% probability levels.

Results and Discussion

Physiological parameters

Cropping system had significant effect on physiological parameter i.e. leaf area index, crop growth rate, relative growth rate and SPAD (Table 1.). The results of leaf area index significantly affected by cropping system and found maximum leaf area index under MWMB which was significantly higher than cropping system MMuMb at all the growth stages during both the years and mean data over cropping system. The data showed that crop growth rate of maize had significant differences in cropping system and recorded significantly maximum CGR value by MWMB at all the growth stages during both the years and mean data than MMuMb cropping system. The results showed that relative growth rate value significantly affected by cropping system in both years and mean analysis also. With regard to crop growth rate and relative growth rate, MW Mb system gave higher value which was significantly higher than MMMb cropping system. The SPAD value was higher in MWMu cropping system than MMMu. The residue incorporaion in permanent beds significantly increased leaf area index, crop growth rate, relative growth rate, NDVI values and SPAD value as compared to without residue application in both the years. This significant increase physiological parameter due to more nutrient available with MWMu cropping system. Ram, H. (2006) confirmed that physiological parameters i.e. LAI, CGR and RGR found higher values with residue of legume than no-residue under permanent bed.

Nitrogen management practices exhibited greater influence on leaf area index, crop growth rate, relative growth rate, NDVI values and SPAD value during crop growth. The highest leaf area index significantly increased with nitrogen applied by NCU (Neem coated urea) produced taller plants which was significantly than with SCU (sulphur coated urea) and prilled urea (PU). The highest crop growth rate and relative growth rate values was recorded with the application of nitrogen by NCU (Neem coated urea) which was significantly on par with SCU (sulphur coated urea) at most the stages of crop periods in both the years. The data maximum NAR was noted with the application of nitrogen by SCU (sulphur coated urea) which was on par with NCU (Neem coated urea) at all the stages during both the year respectively. These increases of the parameters under investigated may be due to the amount of metabolites synthesized by plants as a result of increasing nitrogen levels. This may be attributed to the favorable effect of nitrogen fertilizer levels on the metabolic processes and physiological activates of meristimatic tissues, which are responsible for cell division and elongation in addition to formation of plant organs this lead to more vigorous growth and consequently accumulation of more photosynthesis assimilates. The application of various nitrogen management strategies lead to significant influence on the various physiological parameters in intensified maize systems. The nitrogen applied by NCU or SCU lead to enhancement in CGR, RGR and NAR at most of the crop growth stages control. The lower physiological indices in the absolute control may be attributed to lower dry weight and leaf area of the plant at initial growth stages observed in our study which caused more net assimilation of photosynthates with per unit of leaf area in maize. Moreover, the application of N fertilization resulted in timely tasseling and silking in maize compared to control where it got delayed by 7 to 11 days. However, the maturity was arrived on same time which resulted in decreasing of reproductive period of crop by almost 11 days. This could be attributed to better growth parameters of leaf area of the crop with N fertilization compared to control which helped in achieving crop developmental stages on time. Mohanty *et al.* (2015) [11] and Ghosh (2015) [9] stated that that the increases in the maize leaf area, SPAD and NDVI was found to increased with better nutrient management under conservation agriculture compared to conventional farmers fertilization practices under maize in sandy loam soils.

Table 1: Effect of cropping system, residue and nitrogen management practices on leaf area index in maize

Treatments	Leaf area index											
	30 DAS			45 DAS			60 DAS			90 DAS		
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
Cropping system												
Maize-mustard-mungbean	1.505	1.565	1.535	2.916	3.021	2.969	4.143	4.231	4.187	2.388	2.475	2.431
Maize-wheat-mungbean	1.830	1.909	1.869	3.074	3.188	3.131	4.509	4.622	4.566	2.607	2.718	2.662
S.Em. ±	0.006	0.014	0.006	0.010	0.018	0.007	0.015	0.019	0.010	0.006	0.006	0.014
CD at 5%	0.037	0.084	0.039	0.061	0.110	0.044	0.095	0.114	0.063	0.034	0.035	0.089
Residue management												
Permanent beds - residue	1.556	1.617	1.587	2.945	3.033	2.989	4.258	4.354	4.306	2.425	2.517	2.471
Permanent beds + residue	1.779	1.856	1.817	3.045	3.176	3.110	4.394	4.500	4.447	2.569	2.676	2.622
S.Em. ±	0.008	0.015	0.010	0.015	0.006	0.003	0.020	0.034	0.006	0.013	0.013	0.011
CD at 5%	0.029	0.057	0.038	0.059	0.025	0.011	0.077	0.133	0.022	0.051	0.051	0.045
Nitrogen management												
Absolute control	1.424	1.481	1.452	2.658	2.734	2.696	3.796	3.899	3.848	2.280	2.378	2.329
N by prilled urea (PU)	1.655	1.732	1.693	2.959	3.032	2.995	4.291	4.391	4.341	2.462	2.568	2.515
N by sulphur coated urea (SCU)	1.740	1.804	1.772	3.087	3.231	3.159	4.537	4.627	4.582	2.574	2.674	2.624
N by neem coated urea (NCU)	1.851	1.930	1.890	3.277	3.422	3.349	4.680	4.790	4.735	2.672	2.765	2.718
S.Em. ±	0.018	0.020	0.019	0.030	0.040	0.033	0.050	0.052	0.055	0.030	0.031	0.028
CD at 5%	0.051	0.058	0.055	0.088	0.116	0.096	0.146	0.152	0.161	0.087	0.089	0.082

Table 2: Effect of cropping system, residue and nitrogen management practices on crop growth rate (g/day) in maize

Treatments	Crop growth rate (g/day)											
	0-30 DAS			30-45 DAS			45-60 DAS			60-90 DAS		
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
Cropping system												
Maize-mustard-mungbean	0.878	0.905	0.892	1.485	1.537	1.511	3.128	3.208	3.168	2.996	3.005	3.000
Maize-wheat-mungbean	0.915	0.936	0.925	1.984	2.036	2.010	3.950	4.120	4.035	2.729	2.684	2.706
S.Em. ±	0.007	0.005	0.005	0.008	0.007	0.008	0.012	0.011	0.011	0.021	0.021	0.019
CD at 5%	0.043	0.031	0.031	0.049	0.043	0.049	0.074	0.068	0.068	0.130	0.130	0.117
Residue management												
Permanent beds - residue	0.862	0.882	0.872	1.651	1.712	1.681	3.305	3.406	3.356	2.949	2.938	2.944
Permanent beds + residue	0.931	0.959	0.945	1.818	1.861	1.839	3.772	3.922	3.847	2.775	2.750	2.763
S.Em. ±	0.013	0.009	0.013	0.011	0.009	0.020	0.023	0.022	0.024	0.025	0.026	0.024
CD at 5%	0.051	0.035	0.051	0.043	0.035	0.078	0.090	0.086	0.094	0.098	0.102	0.094
Nitrogen management												
Absolute control	0.604	0.618	0.611	1.647	1.707	1.677	2.833	2.923	2.878	2.282	2.288	2.285
N by prilled urea (PU)	0.885	0.902	0.894	1.646	1.719	1.683	3.252	3.356	3.304	2.446	2.436	2.441
N by sulphur coated urea (SCU)	1.025	1.060	1.042	1.777	1.823	1.800	3.977	4.085	4.031	3.262	3.235	3.249
N by neem coated urea (NCU)	1.071	1.103	1.087	1.868	1.896	1.882	4.094	4.291	4.192	3.459	3.418	3.439
S.Em. ±	0.019	0.018	0.015	0.021	0.022	0.020	0.040	0.044	0.036	0.077	0.067	0.054
CD at 5%	0.056	0.052	0.044	0.063	0.065	0.057	0.117	0.130	0.105	0.224	0.195	0.159

Table 3: Effect of cropping system, residue and nitrogen management practices on normalized difference vegetation index (NDVI) values in maize

Treatments	NDVI values											
	30 DAS			**45 DAS**			**60 DAS**			**90 DAS**		
	2016	**2017**	**Mean**	**2016**	**2017**	**Mean**	**2016**	**2017**	**Mean**	**2016**	**2017**	**Mean**
Cropping system												
Maize-mustard-mungbean	0.383	0.394	0.388	0.585	0.595	0.590	0.592	0.621	0.596	0.560	0.566	0.566
Maize-wheat-mungbean	0.410	0.420	0.415	0.587	0.606	0.597	0.654	0.641	0.658	0.568	0.572	0.572
S.Em. ±	0.001	0.001	0.001	0.003	0.002	0.002	0.001	0.001	0.001	0.000	0.003	0.000
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Residue management												
Permanent beds – residue	0.379	0.390	0.385	0.589	0.600	0.594	0.619	0.628	0.623	0.538	0.549	0.544
Permanent beds + residue	0.414	0.424	0.419	0.584	0.601	0.593	0.627	0.635	0.631	0.589	0.599	0.594
S.Em. ±	0.002	0.004	0.000	0.003	0.002	0.004	0.003	0.003	0.004	0.000	0.005	0.003
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen management												
Absolute control	0.381	0.388	0.384	0.573	0.583	0.578	0.593	0.605	0.599	0.520	0.530	0.525
N by prilled urea (PU)	0.393	0.403	0.398	0.583	0.603	0.593	0.613	0.620	0.617	0.565	0.580	0.573
N by sulphur coated urea (SCU)	0.408	0.415	0.411	0.591	0.605	0.598	0.635	0.645	0.640	0.580	0.590	0.585
N by neem coated urea (NCU)	0.405	0.423	0.414	0.599	0.613	0.606	0.650	0.655	0.653	0.590	0.595	0.593
S.Em. ±	0.004	0.005	0.005	0.006	0.007	0.007	0.007	0.008	0.008	0.006	0.007	0.006
CD at 5%	0.012	0.014	0.013	0.019	0.021	0.020	0.022	0.024	0.024	0.019	0.021	0.018

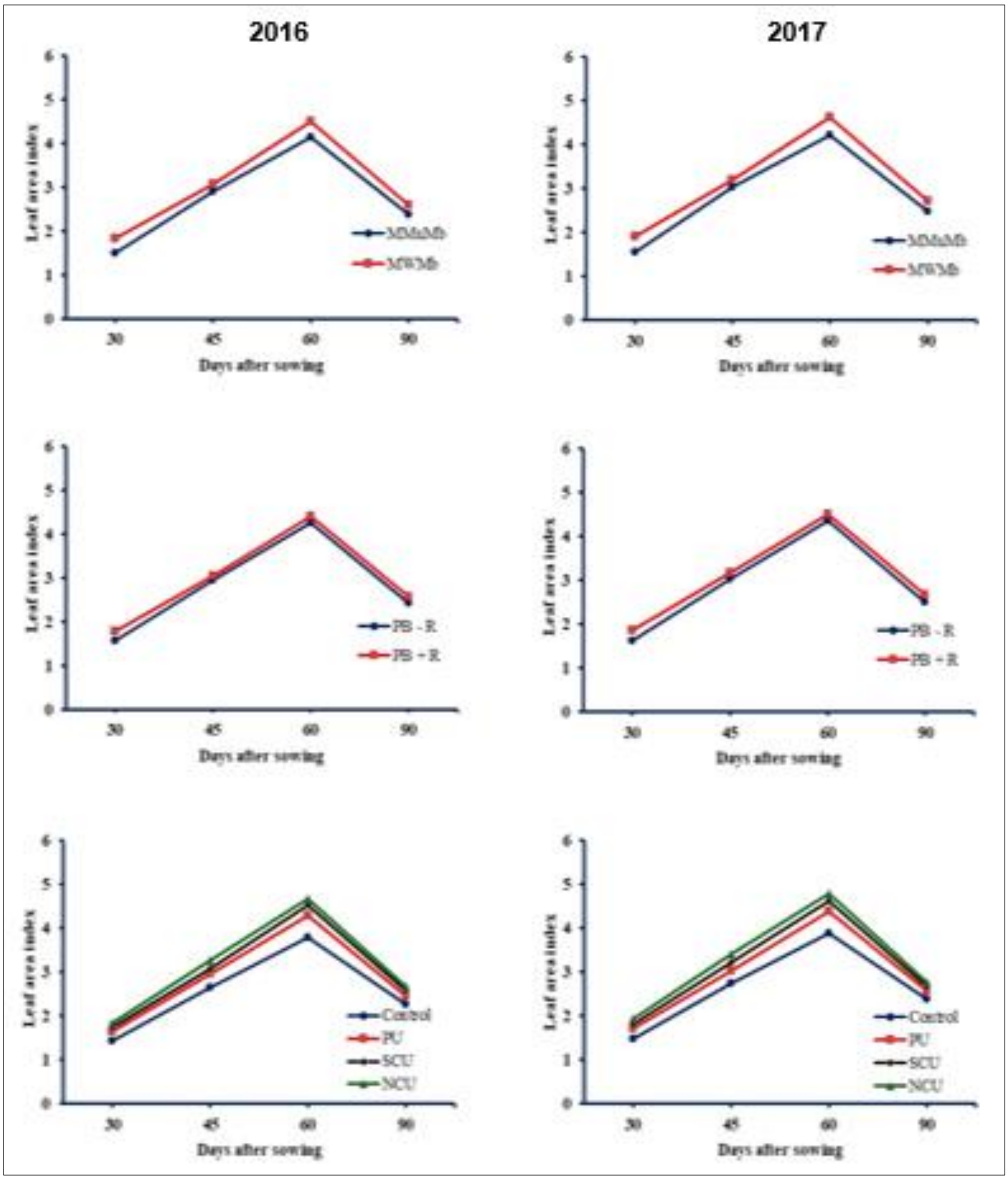


Fig 1: Effect of cropping system, residue and nitrogen management practices on leaf area index in maize at different growth stages

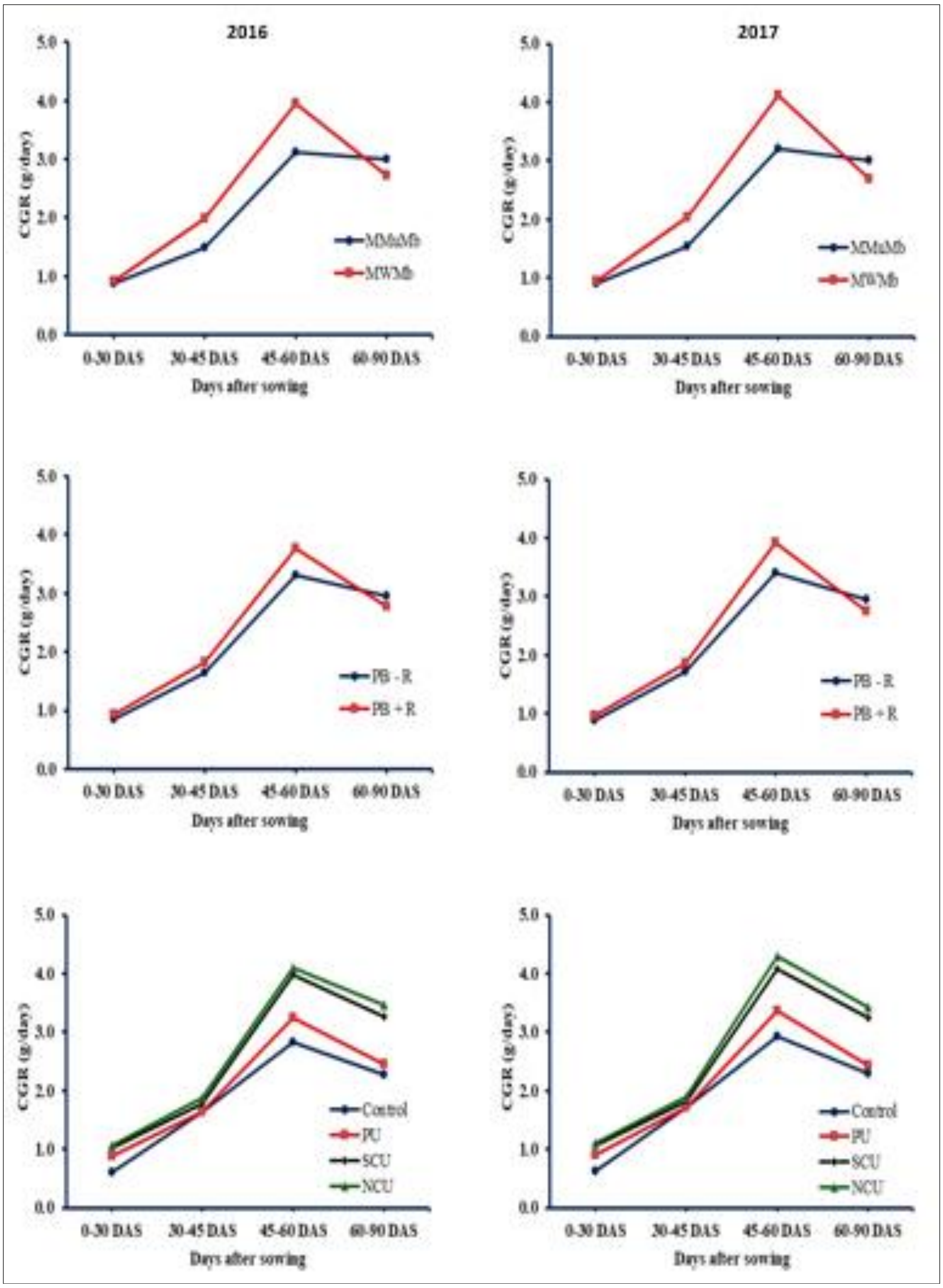
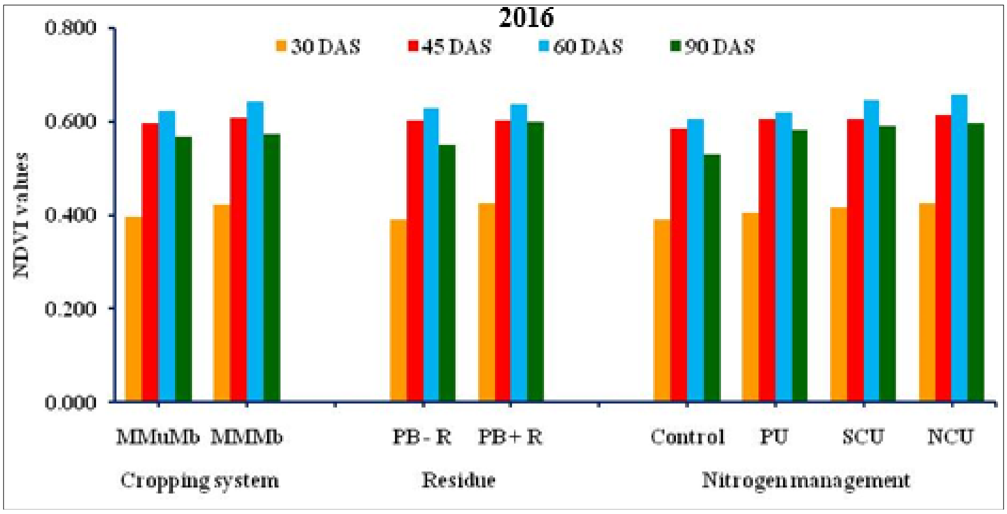


Fig 2: Effect of cropping system, residue and nitrogen management practices on crop growth rate (g/day) in maize



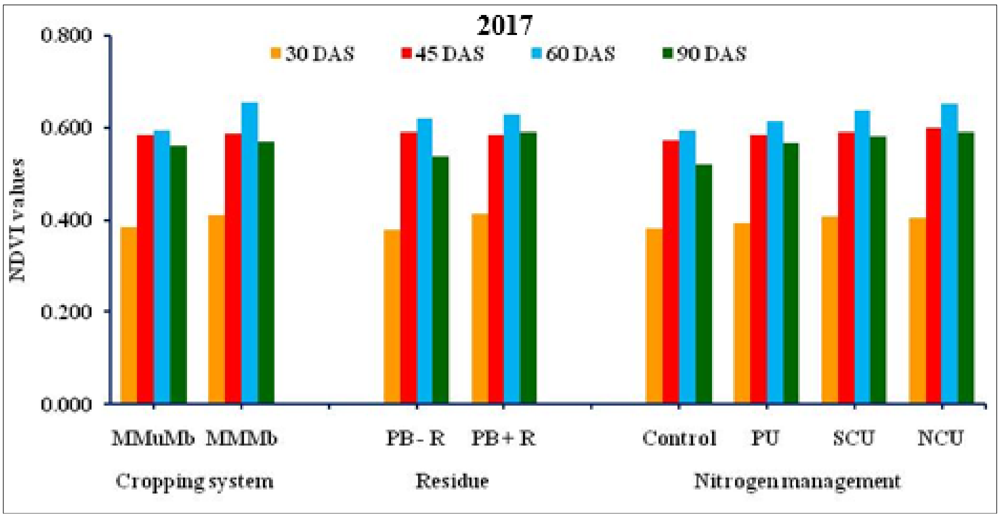


Fig 3: Effect of cropping system, residue and nitrogen management practices on normalized difference vegetation index (NDVI) values in maize

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