Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(4): 2260-2264
Received: 10-05-2019
Accepted: 14-06-2019

Ankita Gudge
P.hd RVSKVV College of Agriculture, Gwalior, Madhya Pradesh, India

Dr. GS Rawat
HOD Agronomy, RVSKVV College of Agriculture, Gwalior, Madhya Pradesh, India

Dr. SL JAT
Scientist Indian Institute Maize Research (IIMR), New Delhi, India

Shweta Tiwari
Scientist Indian Institute Maize Research (IIMR), New Delhi, India

Correspondence
Ankita Gudge
P.hd RVSKVV College of Agriculture, Gwalior, Madhya Pradesh, India

Impact of conservation agriculture and nitrogen management on growth and productivity of maize (*Zea mays* L.)

Ankita Gudge, Dr. GS Rawat, Dr. SL JAT and Shweta Tiwari

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 growth and productivity of maize (*Zea mays* L.) under different cropping system, residue and nitrogen management. The treatments consisted two cropping system i.e Maize-wheat-mungbean-(MWMb), 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 -***(fertilizer No -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 the variation in plant height of maize was significant between cropping system and recorded maximum plant height with MWMb as MMuMb. With regard to dry matter accumulation and leaf area index, MWMb system gave higher value which was significantly higher than MMuMb cropping system. The SPAD value was higher in MWMb cropping system than MMuMb. The residue incorporaion in permanent beds significantly increased plant height, dry matter accumulation, leaf area index and SPAD value as compared to without residue application in both the years. The highest length and width were found under MWMb cropping system which was significantly superior over MMuMb. Significantly more number of cob per hectare, more number of grains/row and higher test weight were recorded under MWMb cropping system as compared to MMuMb cropping system. Highest yields of grain and straw were recorded under MWMb cropping system over MMuMb cropping system. Residue incorporation caused significant effect on the grain and straw yield. The Residue incorporation in permanent beds of maize yielded higher over without residue in permanent beds.
The plant height significantly increased with nitrogen applied by NCU (Neem coated urea) produced taller plants which was significantly on par with SCU (sulphur coated urea) and prilled urea (PU). It was noticed that the application of nitrogen by different sources increased compared with the control treatment. Results also indicated that the application of neem coated urea (NCU) increased the cob length, cob width, number of cobs per hectare and 1000 seed weight of maize plants compared with urea as prilled urea, sulphur coated urea (SCU) source of nitrogen fertilizer. The application of urea from neem coated urea (NCU) produced higher grain, straw and biological yield followed by sulphur coated urea (SCU) and prilled urea (PU) when compared with absolute control. The relative increases in grain yield (128.75, 116.69, 93.20 % and 126.96, 118.83, 93.53 %) and straw yield (91.13, 83.32, 74.85 % and 89.12, 81.59, 73.07 %) in NCU, SCU, PU during 2016 and 2017, respectively.

Keywords: Residue, Sulphur coated urea, neem coated urea, grain yield, yield attributes, 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). 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].
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.

Conservation agriculture (CA) has emerged as a major way forwards from the existing unsustainable mode of crop production (Sharma and Behera, 2007) [15]. 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. 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]. 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 $28^0$38'23,N, $77^{009,}$ 27' E, to with an elevation of 228.6 m from the sea level in a semi arid subtropical climate region. The annual maximum temperature goes up to as high 45 ^oC in summer whereas the minimum temperature dips to as low as -0.5 ^oC 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}). The treatments consisted two cropping system i.e Maize-wheat-mungbean-MWMb, 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 67cm x 20 cm during both the years. 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 growth and yield attributes, grain and straw yields of maize 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

Growth parameters

Cropping system had significant effect on growth attributes i.e. plant height, dry matter accumulation and leaf area index and SPAD (Table 1.) Variation in plant height of maize was significant between cropping system and recorded maximum plant height with MWMb as MMuMb. With regard to dry matter accumulation and leaf area index, MWMb system gave higher value which was significantly higher than MMuMb cropping system. The SPAD value was higher in MWMb cropping system than MMuMb. The residue incorpotaion in permanent beds significantly increased plant height, dry matter accumulation, leaf area index and SPAD value as compared to without residue application in both the years. This significant increase in growth attributes due to more nutrient available with MWMb cropping system. Ram, H. (2006) [13] confirmed that growth parameters i.e. plant height, dry matter accumulation, LAI, CGR and RGR found higher values with residue of legume than no-residue under permanent bed.

Nitrogen management practices exhibited greater influence on the height of the plant, dry matter production, leaf area index and SPAD value during crop growth. The plant height significantly increased with nitrogen applied by NCU (Neem coated urea) produced taller plants which was significantly on par with SCU (sulphur coated urea) and prilled urea (PU). 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. Mohanty *et al.* (2015) [11] and Ghosh (2015) [9] stated that that the increases in the maize plant height, leaf area, dry matter production 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.

Yield attributes

As regards the influence of cropping system on yield contributing characters, Number of cobs/ha, cob length (cm), cob length (cm), number of grain/row, 1000 grain weight (g) were positively influenced (Table 2). The highest length and width were found under MWMb cropping system which was significantly superior over MMuMb. Significantly more number of cob per hectare, more number of grains/row and higher test weight were recorded under MWMb cropping system as compared to MMuMb cropping system. Perhaps this might have been possible due to the fact suitable condition for better growth and available more nutrients which benefited the plants in utilizing higher amount of inputs. Residue incorporated in permanent beds affects the yield attributing characters of maize and found maximum under Residue incorporated in permanent beds which was significant than without residue application. Mulch application increased the SOM and reduced soil bulk density, thereby improving soil porosity and aeration (Tejada *et al*. 2008) [18], which also supported the formation of larger water stable aggregates, and then increased bio-pores that improved the growth of roots (Rasool *et al*. 2008) [14] and promote the crop growth and development. The GM treatment was better than the SM treatment in improving rice grain and straw yields as it created a more conducive edaphic environment for plants and supplied additional N (2.5% N content) (Kumar *et al*. 2013) [5]. On the other hand, CA may also have detrimental impacts on crop yield by altering soil physiochemical and biological conditions, such as decreasing soil temperatures in areas of high latitude and seasons with low temperature and aggravating weed and disease incidence (Boomsma *et al*. 2010) [4].

It was noticed that the application of nitrogen by different sources increased cob length, cob width, number of cobs per hectare and 1000 seed weight of maize plants compared with the control treatment. Results also indicated that the application of neem coated urea (NCU) increased the above mentioned parameters of maize plants compared with urea as prilled urea, sulphur coated urea (SCU) source of nitrogen fertilizer. These increases of the parameters under investigated may be due to the amount of metabolites synthesized by plants. This may be attributed to the favourable 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. Similar results were reported by Muthukumar *et al*. (2005) [12]. According Ahmad *et al*. (2010) [1] that CT gave superior yield attributes in term of grain weight, grains per cob and grain yield as compared to NT and split application significantly increased grain weight, grains per cob and grain yield as compared to single application of prilled urea.

Table 1: Growth parameters as influenced by cropping system, residue and nitrogen management

Treatments	Plant height (cm)		Dry matter accumulation/plant		Leaf area index		SPAD	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Cropping system								
Maize-mustard-mungbean	186.69	190.90	185.42	188.46	2.388	2.475	36.61	37.09
Maize-wheat-mungbean	192.87	195.09	198.29	200.93	2.607	2.718	36.37	36.54
S.Em. ±	0.83	0.91	1.008	1.282	0.006	0.006	0.137	0.167
CD at 5%	5.12	5.64	6.217	7.912	0.034	0.035	NS	NS
Residue management								
Permanent beds – without residue	186.41	189.64	188.68	191.37	2.425	2.517	36.09	36.42
Permanent beds – with residue	193.15	196.35	195.03	198.01	2.569	2.676	36.88	37.21
S.Em. ±	1.13	1.09	1.071	1.008	0.013	0.013	0.240	0.235
CD at 5%	4.40	4.24	4.181	3.937	0.051	0.051	NS	NS
Nitrogen management								
Absolute control	178.75	181.87	153.78	156.63	2.280	2.378	34.64	35.09
N by prilled urea (PU)	188.99	192.63	173.41	176.27	2.462	2.568	35.84	35.94
N by sulphur coated urea (SCU)	193.82	197.15	214.91	217.45	2.574	2.674	37.16	37.57
N by neem coated urea (NCU)	197.57	200.33	225.33	228.42	2.672	2.765	38.30	38.67
S.Em. ±	2.32	2.10	2.418	2.357	0.030	0.031	0.326	0.478
CD at 5%	6.77	6.12	7.060	6.881	0.087	0.089	0.952	1.396

Table 2: Yield attributes of wheat as influenced by cropping system, residue and nitrogen management

Treatments	Number of cobs/ha		Cob length (cm)		Cob girth (cm)		Grains/row		1000 grain weight (g)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Cropping system										
Maize-mustard-mungbean	57.05	58.12	15.38	15.52	12.82	12.89	30.75	31.53	238.27	239.44
Maize-wheat-mungbean	64.33	65.73	16.41	16.50	13.41	13.49	32.43	32.94	248.44	251.28
S.Em. ±	0.420	0.467	0.119	0.127	0.057	0.062	0.114	0.105	0.84	0.92
CD at 5%	2.591	2.881	0.734	0.783	0.352	0.382	0.703	0.648	5.18	5.67
Residue management										
Permanent beds – without residue	58.99	60.12	15.54	15.70	12.97	13.06	31.10	31.77	240.69	242.01
Permanent beds – with residue	62.40	63.73	16.25	16.32	13.25	13.33	32.08	32.71	246.03	248.71
S.Em. ±	0.428	0.400	0.054	0.046	0.060	0.056	0.179	0.123	0.825	0.722
CD at 5%	1.671	1.562	0.211	0.180	0.234	0.219	0.699	0.480	3.222	2.819
Nitrogen management										
Absolute control	55.34	56.34	14.57	14.60	12.49	12.53	27.92	28.77	218.68	220.63

N by prilled urea (PU)	58.67	59.98	15.86	16.00	12.94	13.04	31.33	31.94	246.34	248.34
N by sulphur coated urea (SCU)	62.77	64.01	16.39	16.57	13.44	13.50	33.06	33.54	252.49	254.63
N by neem coated urea (NCU)	66.00	67.37	16.75	16.86	13.59	13.70	34.05	34.71	255.92	257.84
S.Em. ±	0.755	0.716	0.161	0.205	0.168	0.169	0.311	0.404	3.060	2.997
CD at 5%	2.203	2.091	0.470	0.599	0.492	0.492	0.907	1.181	8.933	8.751

Table 3: Grain yield, straw yield, biological yield and harvest index as influenced by cropping system, residue and nitrogen management

Treatments	Cob yield (kg/ha)		Grain yield (kg/ha)		Straw yield (kg/ha)		Harvest index (%)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Cropping system								
Maize-mustard-mungbean	6695.4	6798.0	5219.2	5363.8	10918.8	11023.8	32.01	32.41
Maize-wheat-mungbean	7475.0	7577.0	5925.8	6084.4	11779.4	11886.7	33.07	33.41
S.Em. ±	45.3	50.2	28.0	32.4	67.0	63.1	0.22	0.23
CD at 5%	279.4	309.6	172.7	199.8	413.3	389.2	NS	NS
Residue management								
Permanent beds – without residue	6847.0	6945.0	5338.2	5508.4	11072.8	11147.4	32.17	32.69
Permanent beds – with residue	7323.4	7430.0	5806.9	5939.8	11625.5	11763.1	32.90	33.13
S.Em. ±	43.5	47.1	38.3	40.4	32.3	29.9	0.22	0.27
CD at 5%	169.8	183.9	149.5	157.7	126.1	116.7	NS	NS
Nitrogen management								
Absolute control	4053.2	4118.5	3017.7	3097.0	6991.6	7117.5	30.16	30.34
N by prilled urea (PU)	7463.9	7584.0	5830.2	5993.5	12224.8	12318.1	32.27	32.72
N by sulphur coated urea (SCU)	8218.3	8353.5	6539.2	6777.1	12817.2	12924.4	33.72	34.34
N by neem coated urea (NCU)	8605.4	8694.0	6903.0	7028.9	13362.9	13460.8	34.01	34.25
S.Em. ±	76.0	69.1	67.2	56.4	153.0	148.6	0.30	0.29
CD at 5%	221.8	201.7	196.2	164.5	446.6	433.7	0.88	0.84

Grain and straw yield

Cropping system and residue management had quite appreciable influence. Highest yields of grain and straw were recorded under MWMb cropping system over MMuMb cropping system. The increase in grains and straw yield may be attributed mainly to higher number of cobs per hectare, more number of grains per row and 1000 grain weight which was highly favored under MWMb cropping system. Residue incorporation caused significant effect on the grain and straw yield. The Residue incorporation in permanent beds of maize yielded higher over without residue in permanent beds. The marked increase in grain yield in above treatments might be due to over all improvement on yield attributes. Residue retention was essential to maintain productivity of maize and realize the benefits of direct drilling. ZT with residue retention and crop rotation resulted in high stable yields due to soil with good physical and chemical qualities compared to CT and ZT without residue (Govaerts *et al*., 2005) [10].

A perusal of the data presented in table 3 clearly revealed that all the treatments significantly influenced the grain and straw yield over control during both the years. Generally, the application of urea from neem coated urea (NCU) produced higher grain, straw and biological yield followed by sulphur coated urea (SCU) and prilled urea (PU) when compared with absolute control. The relative increases in grain yield (128.75, 116.69, 93.20 % and 126.96, 118.83, 93.53 %) and straw yield (91.13, 83.32, 74.85 % and 89.12, 81.59, 73.07 %) in NCU, SCU, PU during 2016 and 2017, respectively. Increases in grain and straw yields might be due to increasing in growth and yield attributes of maize due to slow release nitrogen fertilizer and application of urea as slow release nitrogen fertilizer maintained the nitrogen losses as volatilization or leaching. These results may be due to that sandy soil is very low water holding capacity and high nutrient leaching losses. Tanwar (2014) [17] reported that neem coated urea significantly increased nutrient availability and uptake by maize crop, which gave higher grain and stover yield. Almost similar findings were also reported by Sharma and Prasad (1996) [16] and Upadhyay and Tripathi (2000) [19], Gagnon *et al.* (2012) [8].

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