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Response of late sown maize (*Zea mays*) to organic nutrient sources and rate of application in fragile ecosystem of Meghalaya in acidic soil

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Abstract

The field experiment was conducted at Instructional Farm of College of Agriculture (CAU-I), Kyrdemkulai, Meghalaya during *kharif* season of 2020-21 to study the response of late planting of maize to different sources and rate organic manure (poultry manure, neem cake and *Azotobacter*).The experiment was planned in randomized block design with eleven treatments consisting of combination of rates and sources of organic manure in maize (DA-61-A). Results showed that, application of poultry manure (PM) or neem cake (NC) equivalent to 100 % N (120 kg N /ha) remain on par with PM (100 % N) + NC (100 % N) in all studied growth attributes. Application of *Azotobacter* + PM (50 % N) or NC (50 % N) found to increase plant height and dry matter accumulation than application of PM (50 % N) or NC (50 % N) alone. Dry matter portioning at harvest showed that, out of total plant biomass at harvest, 57 to 59.5 % is accumulated in cob and order of significance of dry matter accumulation was cob > stem > leaf > root > tassel. Our study also showed that, crop performance was sub-optimal in late planting condition and maize cobs can't able to fill with grain and showed rottening mainly due to abiotic stresses such as rainfall and infection by fungal growth.

Keywords: Organic farming, maize, poultry manure, neem cake.

Introduction

The maize is second important crops after rice in Meghalaya grown on 18152 ha area with production and productivity of 41,624 metric tonne and 2293 kg/ha, respectively. The fragmented and small area, growing on raised bed, wider window of sowing from March to June and up to August in case of late sowing, prominence of maize–legume (pea and French bean) cropping system, organic production system, wider spacing and intercropping with cowpea and early sown pea are the important characters of maize grown in the Meghalaya. The varietal development for higher rainfall condition, land relief leading to easy removal of stagnating water, light soil texture leading to ease in drainage of water andsoil richness in organic matter (Choudhury *et al*., 2013) make maize cultivation possible in state; while predominance of animal-based enterprises in farming system creates scope for maize cultivation in the state. Out of total maize production in India, 60 % is used as animal feed (including poultry), 14 % for starch extraction and 7 % as processed food (FICCI, 2018). Besides that, maize has highest commercially utilizable species diversity such as baby corn, pop corn, sweet corn and waxy corn (Yadav *et al*., 2014). Considering its diversified uses and higher productivity, maize is getting new identity as 'promising cereal' due to its capacity to handle the batten of food security and also called as 'future cereal' due to its productivity can be increases and yet there is no yield stagnation achieved and also due to highest genetic potential of maize. The species diversity in maize and multiple uses of maize can be effective way of compensate the lower yield in organic production system as the products of speciality maize fetches higher prices in market than price of grain crops. The baby corn matures within 50-60 days and produce valuable green fodder after harvesting of cobs. The early harvesting helps in accommodating another crop thereby increasing cropping intensity. The fodder scarcity is common in the state during winter season and dependence on forest vegetation for fodder can be reduced to a great extends by growing baby corn and sweet corn. Considering this, maize will be an important component of animal-based farming system of the Meghalaya state in India.

Maize is high yielding crop and setiyono *et al*. (2010) reported that, for irrigated maize yielding 5 t grain yield/ha, 82 kg N, 12 kg P and 80 kg K will be required nutrient uptake. Meeting these nutrient requirements in organic production system and testing it for productivity level achieved need to be evaluated in fragile ecosystem of Meghalaya which constraints yield level due to erosion of top fertile soil, washing out of manure applied along with soil and soil acidity. Besides these constraints, quantity of manure required for meeting the nutrient requirements and cost involved, quality of manure available at farmers end (nutrient content), lack of facility and awareness about significance of process/ enrichment of row manure and difficulty in quantification of nutrient added through organic manure are major consideration for nutrient management through organic mode in the state. As the manure and get washed away with runoff water, there is possibility of response of maize to higher rate of nutrient application than recommended as well as in-season nutrient management.In case of high intensity of rainfall and steep land relief with shallow soil, the losses of manure and soil too is very severe (at field level) leading to non-reaching of crop to maturity or bearing cob with few or vey less grains; while as crop is still grown in small area, the intensive care is possible to avoid such losses.

In order to assess the potential of crop in fragile ecosystem with available soil resources and agro-climatic conditions as well as with different stresses (biotic and abiotic), it is needed to evaluate maize without any intensive care and with recommended management practices and input addition. The susceptibility of maize to different biotic stresses is well know with a new pest fall army worm causing significant damage to crop (Firake *et al*., 2019); while weed problems during early growth stage will be common due to wider spacing and continuous water availability through rainfall. The significance of abiotic stress is much higher in fragile ecosystem and their impact on crop growth changes with input addition and management practices. The practices such as changing sowing time and rate of input addition especially nutrients in organic farming expected to changes the impact of abiotic stresses on crop growth. With this background that, study was conducted with objective to study the growth response of maize torate and sources manure for crop nutrition in late sown condition.

Materials and Methods

The field experiment was conducted at Instructional Farm of College of Agriculture (CAU-I), Kyrdemkulai, Meghalaya located at 25^0 74′ N latitude, 91^0 81′ E longitude and 700 meter above mean sea level during *kharif* season of 2020-21.The climate of selected area is subtropical with average seasonal (June to September) and annual rainfall of 1424.1 mm and 2119.3 mm, respectively. The land cleared off from forest vegetation in 2019 and sown with oat (*Avena sativa*) in *rabi* season of 2019. The field was prepared by giving two pass of power tillers followed by collection of stubbles. The experiment was conducted in randomized block design (RBD) involving eleven treatment combinations and replicated thrice. Thetreatment involves organic sources of nutrients viz., poultry manure, neem cake and bio-fertilizer (*Azotobacter*) and different rate of application of these manures (Table 1). The rate of manure application was decided by considering nitrogen requirement of 120 kg/ha as 100 % recommended rate of nitrogen application. The bio-fertilizer (*Azotobacter*) was applied @ 250 g/10 kg seeds at the time of sowing by making slurry in water. The entire quantity of manure was applied below the seed manually by making a shallow depressing using row maker one day before the sowing. Sowing (Variety: DA-61-A) was done on 24th June 2020 by dibbling 1-2 seeds at spacing 50×20 cm in flat beds. Gap filling was done twice at 10 and 15 DAS. The field was weeded two time 25 and 45 days after sowing (DAS) and no any irrigation was given. For management of fall army worm, cultural practices such as hand picking, application of mud/ soil inside whorls in early growth stage and spraying of neem seed kernel extract was done (5%) was done. Plant population count was taken at three times at 30 days interval for entire plot; while plants with cob and tassel were counted at 60 DAS and at harvest. Plant height measured by taking height of topmost leaf at 30 and 60 DAS and height of tassel at harvest. Above ground dry matter accumulation was measured by sun drying followed by oven drying at 60 ± 2^0C temperature till constant weight achieved. At harvest, dry matter portioning was recorded by measuring the weight of stem, leaf, root, tassel and cob. The statistical significance among applied treatments were studied using the F-test and least significant difference (LSD) values (*P* = 0.05).

Results and Discussion

Survival of maize plants

The crop survival and growth is significantly affected by heavy rainfall and washing of soil along with manures and in some cases uprooting of seedling due to runoff flow and erosion of soil. Hence the plant population showed variation across treatments even through the seed rate and gap filling was done uniformly in all plots (Table 1). The higher plant population in all treatments at 30 DAS was due to sowing of 1-2 seeds at each spot; while its decreases at 60 and at harvest with highest decrease in control and *Azotobacter* applied treatment. The total number of plants at harvest with PM (100 % N), NC (100 % N) and PM (50 % N) + NC (50 % N) were 38 %, 41 % and 38 % higher than that of control, respectively; while total number of plants bearing cobs were higher by 86 %, 86 % and 100 % (doubles) respectively over control. This indicates that, delay in sowing adversely affect the plant population and application of 100 % N through any source alleviate the effect even though both gap filling and sowing specification are important in this regards. Beyond survival of plant, rate of manure applica-

Table 1. Effect of nutrient application through organic sources on survival and growth attributes of maize plants

Treatments	Total plants per plot*			Plant with tassel*		Plant with cods/ silk*		Plant height (cm)			Dry matter accumulation (g/plant)		
	30 DAS	60 DAS	At harvest	60 DAS	At harvest	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
Control	58	36	34	22	20	13	15	48.6	86.0	89.7	9.0	11.7	23.0
Poultry manure (PM) (equivalent to 50 % N)	60	48	41	33	30	20	21	79.3	152.0	181.0	13.3	20.3	58.7
PM (100 % N)	61	57	47	42	35	22	28	87.3	166.0	197.0	20.7	28.3	68.7
Neem cake (NC) (50 % N)	61	47	41	33	30	21	20	78.3	152.3	181.0	13.7	21.7	59.6
NC (100 % N)	64	56	48	43	34	22	28	89.0	166.0	198.0	21.0	28.3	69.7
Azotobacter (Azt) (25 g/kg seeds)	64	36	35	25	22	16	16	55.3	93.6	97.7	10.7	13.7	27.3
Azt (25 g/kg seeds) + PM (50 % N)	61	50	42	36	31	19	22	80.7	153.3	188.3	17.0	23.3	62.7
Azt (25 g/kg seeds) + NC (50% N)	61	49	42	37	32	20	24	80.0	154.7	186.3	16.7	22.7	61.7
PM (50 % N) + NC (50 % N)	65	57	47	43	36	23	30	87.0	165.7	203.3	20.3	29.3	70.0
Azt (25 g/kg seeds) + PM (50 % N) + NC (50 % N)	66	58	47	44	36	24	31	87.7	166.0	205.3	20.7	29.0	70.7
PM (100 % N) + NC (100 % N)	65.	58	49	45	37	25	31	88.3	168.3	207.6	22.3	32.3	71.0
CD (P= 5%)	2.2	1.7	1.8	2.6	1.6	1.7	2.2	2.66	4.80	2.62	1.28	1.22	2.15

(*: The ideal plant population: 50 plants/plot ($5m^2$ area)); DAS: days after sowing tion play important role in promotion of reproductive growth of crop plants which can be seen from significantly higher plant with tassel and cob in treatment with application of 100 % N through poultry manure or neem cake or combined application of both. Numbers of plant bearing cobs were lower than plant with tassel in all treatment indicating the deficiency on nutrient at cob formation stage. The significance of in-season N application at silking stage was reported by Nasielski and Deen (2019). Significance response of maize to manure application in terms of increasing yield attributes was reported by Saha *et al*. (2007); while Meena *et al*. (2020) showed significance of superiority of split application of nitrogen over basal application. In case of organic farming, in-season nutrient management is conditioned by nutrient release pattern, application methods and nutrient content. It is also expected that, slow nutrient release from organic manures applied at sowing will release the nutrients over extended period and synchronize the nutrient demand. Use of oilcakes and enriched manure such as vermi-compost (Barik *et al*., 2011) will be possible options for in-season nutrient management in organic farming; while timing and rate of application is also depends on rainfall and soil relief along with plant need in Meghalaya (high rainfall and relief).The treatment with application of PM (100 % N) + NC (100 % N) and *Azotobacter* (25 g/kg seeds) + poultry manure (50 % N) + neem cake (50 % N) recorded highest plant with tassel (36 and 37 (No.), respectively) and cobs (31 (No.) in both treatments) at harvest.

Plant height

Plant height was significantly affected due to different rate of application; while the sources (neem cake, poultry manure and mixture of both) didn't show any significance (Table 1). The highest plant height was recorded with combined application of poultry manure and neem cake [PM (100 % N) + NC (100 % N)] (207.6 cm) and remains on par with other two treatments consisting of poultry manure (50 % N equivalent) + neem cake (50 % N equivalent) with and without *Azotobactor* application. The increase in plant height at harvest in treatment involving PM (100 % N) + NC (100 % N) were 4.3 cm and 117.9 cm over PM (50 % N) + NC (50 % N) and control, respectively. This indicates responsiveness of maize to even higher rate than recommended due to washing out of nutrient applied at sowing and recognize need of in-season application in organic maize cultivation. Application of *Azotobactor* alone was found significantly superior over absolute control at 30 and 60 DAS and also at harvest, indicating their role in crop growth. The combined application of *Azotobacter* with either 50 % or 75% recommended dose of N was reported by Laxminarayana (2001); while role of *Azotobacterchroococcum*in absorption of plant nutrients and yield improvement was reported by Song *et al*. (2021). In our study application of *Azotobacter* alone found inferior than application of 50 % N through any source; while application with 50 % N either through poultry manure or neem cake found superior over application of both manure alone.

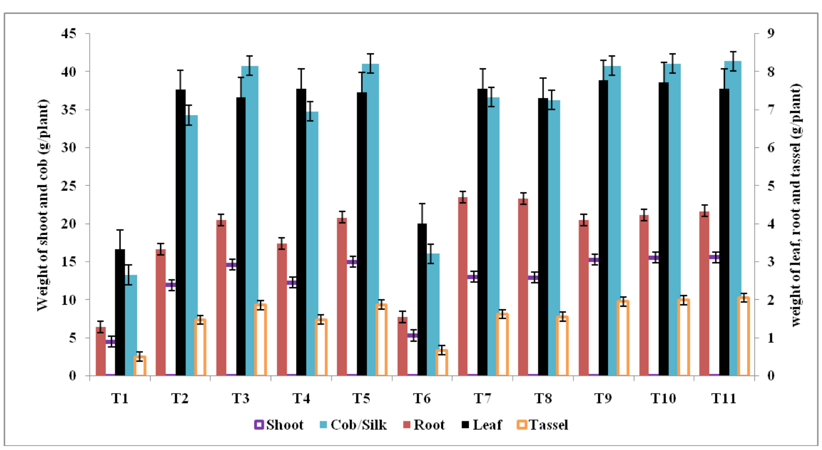

Fig. 1. Partitioning of dry matter in maize (g/plant) as influenced by organic sources of crop nutrition at harvest

Dry matter accumulation and partitioning

Above ground dry matter accumulation differ significantly from 30 DAS onwards for the rate of nutrient application. For source, poultry manure and neem cake was differ significantly at 50 % N application both at 60 and at harvest; while application at 100 % N, the difference was remain non-significant (Figure 1). The possible reason for neutralizing significance of sources of nutrition was washing of manure and changes in nutrient release pattern due to soil moisture. Saha *et al*. (2007) and Choudhary and Suresh Kumar (2013) reported variation in growth and yield of maize due to rate and source of nutrition. The total dry matter accumulation at harvest varies between 23 to 71 g/m^2 with highest in poultry manure (100 % N) + neem cake (100 % N). The dry matter partitioning at harvest showed that, cob has highest dry matter accumulation and the share of cob in total dry matter accumulation at harvest was 57 to 59.5 %. The order of significance of dry matter accumulation was cob > stem > leaf > root > tassel. The combined application of poultry manure and neem cake each at 100 % N equivalent had highest weight of all the studied plant parts; while another two treatments viz. poultry manure (50 % N equivalent) + neem cake (50 % N equivalent) and poultry manure (50 % N equivalent) + neem cake (50 % N equivalent) + *Azotobactor* remain on par with it. This indicates that, application of nutrient higher then recommended rate of nitrogen does not produce and additional dry matter at harvest even though they produce higher plant hight. Even though cob has highest share in total dry matter at harvest, the size of cob and cob filling percentage was very less and due to that, yield attributing characters and as well as grain and straw yield was not recorded in the experiment. The probable reasons for this are washing out of nutrients due to heavy rainfall, non-synchronous maturity due to gap filling and variation in germination time, soil variation with respect to fertility (as the soil erosion from top to bottom layer due to high intense rainfall), wilting of few plant in plot with sub-optimal fertilization, establishment of plant population, incidence of stem borer and poor root development.

Conclusion

Our study showed that, combined application of poultry manure (PM) (equivalent to 100 % N) (120 kg/ha) + neem cake (NC) (equivalent to 100 % N) (71.0 g/m^2) remain on par with application of NC (100 % N) (69.7 g/m^2) for total dry matter accumulation at harvest indicating role of slow release of nutrient from NC. Application of *Azotobactor* (25 g/kg seeds) + PM (50 % N) + NC (50 % N) 70.7 g/m^2 dry matter accumulation at harvest and remain on par with treatment involving PM (100 % N) + NC (100 % N) indicating their potential role in maize nutrition in late planting in organic production.

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