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Effect of integrated nutrient management on agroclimatic environment and yield of baby corn (*Zea mays* L.) in Punjab, India

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ABSTRACT

The experiment was conducted at the Punjab Agricultural University, Ludhiana during 2013 and 2014 on sandy loam soil to study the effect of integrated nutrient management (INM) on microclimatic variations, yield and yield attributes of baby corn (*Zea mays* L.). Results showed that the microclimatic parameters as well as yield and yield attributes of baby corn were significantly influenced by the treatments. At 60 days after sowing the maximum photosynthetically active radiation interception (93.2 %) and lowest soil and canopy temperature (29.8 and 32.0 ^{0}C) was recorded by the application of N-P-K 75-15-11.3 kg ha^{-1}. The corn yield and yield attributes, LAI and chlorophyll content were also significantly higher in this treatment.

Keywords : Baby corn; PAR interception; INM and LAI.

Maize, the third most important cereal crop in the world following wheat and rice, has been cultivated for centuries as a grain crop and more recently as a vegetable crop, such as baby corn and sweet maize (*Zea mays* var. saccharata). Maize is classified into different groups or types based on the endosperm of kernels among which baby corn is grown for vegetable purpose. Baby corn is the young, finger-length fresh maize ear harvested within 2 or 3 days of silk emergence but prior to fertilization (Muthukumar *et al.* 2005). Baby corn is a delicious and nutritive vegetable consumed as natural food. Baby corn cultivation being a relatively new practice in India, requires the development of suitable production technology in realizing higher baby corn yield and monetary returns before it could be popularized among maize growers. Plant biomass production depends on the absorption of photosynthetic photon flux density (PPFD) by its leaves and on the efficiency of the plant to convert solar radiation into chemical energy by the photosynthetic process. The amount of absorbed PPFD depends on the efficiency of radiation interception by the canopy, which in turn depends on plant morphology and physiology. An accurate determination of daily intercepted PPFD is often a critical step in crop simulation models which aims at estimating increases in daily biomass and kernel number (Lindquist *et al.*, 2005).The efficiency of PPFD interception influences the photosynthesis and transpiration processes (Thorpe, 1978). This efficiency depends on the leaf area index (LAI) and on the extinction coefficient, which is related to the canopy structure, especially concerning the shape of the leaf and its inclination (Lindquist *et al.*, 2005). Alterations in the extinction coefficient that shows a constant LAI tend to promote alterations in the intercepted solar radiation, and hence, in the potential accumulation of biomass. The objective of this analysis was to examine the effects of INM on variation in intrercepted PAR and temperature on potential baby corn (*Zea mays* L.) yield.

MATERIALS AND METHODS

The field experiment was conducted at Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana, during 2013 and 2014. The soil of the experimental site was sandy loam in texture with 0.29 % organic carbon, 185.2 kg ha^{-1} available nitrogen, 19.8 kg ha^{-1} available phosphorous and 224.7 kg ha^{-1} available potassium. The experiment was laid out in randomized complete block design with four replications and ten treatments *i.e.* (i) Control (unfertilized), (ii) Recommended N (60 kg ha^{-1}), (iii) N-K; 60-6; kg ha^{-1}, (iv) N-P; 60-12; kg ha^{-1}, (v) N-P-K;45-9-4.5; kg ha^{-1}, (vi) N-P-K; 60-12-6; kg ha^{-1}, (vii) N-P-K; 75-15-11.3; kg ha^{-1}, (viii) 30 kg N ha^{-1} (FYM) + 30 kg N ha^{-1}(through Urea), (ix)15 kg N ha^{-1}(FYM) + 45 kg N ha^{-1} (through Urea) and (x)15 kg N ha^{-1}(FYM) + 60 kg N ha^{-1}(through Urea). The variety 'Composite Kesri' was sown in last week of June 2013 and 2014 at 30 x 20 cm spacing and cobs were harvested at end of August. Nitrogen was given in the form of urea, phosphorus in the form of single super phosphate and potassium in muriate of potash. The nitrogen was applied in two splits irrespective of treatments. Half of nitrogen (as per treatment level) and full doses of phosphorus and potassium was applied at the time of sowing and full dose of organic manures was applied at the time of sowing as per treatment and remaining nitrogen was top dressed 25 days after sowing. SPAD reading (Chlorophyll concentration) was estimated from fully emerged middle leaf of baby corn crop. Leaf area index is a measure of leafiness per unit ground area and denotes the extent of photosynthetic machinery. Harvesting of solar radiation depend upon photosynthetic apparatus of the plant so it is directly related to crop productivity.The crop was detasseled before pollen shed to prevent fertilization and also to divert nutrient flow to developing cob. Crop was grown following recommended packages and practices for the state.

Microclimatic observations

Line quantum sensor (LI-COR photometer Model LI-191-84) was used for PAR measurement. Penetration of PAR (nm) was measured 3 times a day between 9.00 a.m.to 10.00 a.m., 12.00 noon to 1.00 p.m. and 3.00 p.m.to 4.00 p.m. at the top as well as at the base within the crop canopy. The mean values were calculated for further use.The photosynthetically active radiation interception (PARI) by crop was calculated as under:

$$\text{PARI}(\%) = \frac{\text{PAR above the crop} - \text{PAR at soil surface}}{\text{PAR above the crop canopy}} \times 100$$

Soil temperature (°C) was recorded at 5 cm soil depth with a bimetal soil thermometer 2 times a day between 9.00 a.m. to 10.00 a.m. and 2.00 p.m. to 3.00 p.m.. The canopy temperature was recorded by infrared thermometer. The Chlorophyll content was recorded by Spade meter and LAI with plant canopy analyzer (LI-COR). Baby corns were dehusked manually and the yield of both baby corn and fodder was reported on a fresh weight basis.

Statistical analysis

Analysis of variance was performed to determine the effect of integrated nutrient management on microclimatic environment yield and yield attributes of baby corn (*Zea mays* L.). The correlation was analysed using Proc GLM (SAS software 9.1, SAS institute Ltd, USA).

RESULTS AND DISCUSSION

Microclimatic variations

The photosynthetically active radiation interception (PARI %) at 60 days after sowing in baby corn crop as affected by different INM treatments are presented in Table 1. All the INM treatments registered significantly more photosynthetically active radiation interception than standard chemical fertilizer treatment i.e. recommended N (60 kg ha^{-1}). The maximum photosynthetically active radiation interception (93.2%) was recorded in treatment N-P-K; 75-15-11.3; kg ha^{-1} and was statistically at par with treatments 15 kg N ha^{-1} (FYM) + 60 kg N ha^{-1} (through Urea) and N-P-K; 60-12-6; kg ha^{-1}. The higher photosynthetically active radiation interception may be due to more leaf area index and closer spacing (30x20cm) than standard maize crop (60x20 cm) in these treatments. The likely reason for this is that maize leaves absorb 92% of the intercepted radiation by the canopy and efficiency of interception of a canopy corresponds to the capacity of the plant population in intercepting the incident solar radiation, which is the main factor influencing the photosynthesis and the transpiration processes (Müller *et al.,* 2001).

Soil temperature (°C) beneath the crop canopy showed that increase in nutrient level tended to lower soil temperature. The lowest soil temperature was recorded in N-P-K (75-15-11.3 kg ha^{-1}), which may be due to more leaf area index and PAR interception in these treatments as compared to control plot (Table 1). Thus, when a crop intercepts more solar radiation, soil temperature is lowered and has direct correlation with yield in various crops (Kler 1988). The canopy temperature (Table 1) showed similar trend as that of soil temperature. The behind increased canopy temperature under meager nutrition and water stress is probably due to an increase in respiration and a decrease in transpiration as a result of stomatal closure.

Yield attributing parameters

The chlorophyll content was maximum 38.8 in treatment N-P-K (75-15-11.3 kg ha^{-1}) which was statistically at par with treatments15 kg N ha^{-1}(FYM) + 60 kg N ha^{-1} and N-P-K (60-12-6 kg ha^{-1}), which might be due to quick availability of applied fertilizes in these treatments and more labile N availability in the root rhizosphire (Table 1) and their uptake by plants. Similar findings has been reported by Kumar *et al* (2008) while studying the physiological basis of nitrogen use efficiency in maize at various rates of applied nitrogen.

Table 1: Effect of inorganic fertilizers and organic manure on photosynthetically active radiation interception, canopy temperature, soil temperature, leaf area index, chlorophyll content, dry matter accumulation, baby corn and green fodder yield of baby corn (Pooled data of two year 2013 and 2014)

Treatment	PARI %	Canopy temp °C	Soil temp °C	Leaf area index	Chlorophyll content	Dry matter (q/ha)	Baby corn yield (q ha^{-1})	Green fodder yield (q ha^{-1})
Control	62.6	32.8	33.6	2.1	25.6	34.8	7.9	156.1
Recommended N (60 kg ha^{-1})	76.5	32.1	33.4	2.6	31.6	39.5	12.0	212.0
N-K (60-6 kg ha^{-1})	79.7	31.9	33.3	2.8	31.9	41.9	12.5	218.6
N-P (60-12 kg ha^{-1})	82.8	31.9	33.2	3.2	32.1	45.0	12.6	223.4
N-P-K (45-9-4.5 kg ha^{-1})	85.4	30.9	33.2	3.2	32.3	46.8	12.7	228.2
N-P-K (60-12-6 kg ha^{-1})	89.4	30.2	32.7	3.6	36.8	51.6	14.3	258.2
N-P-K (75-15-11.3 kg ha^{-1})	93.2	29.8	32.0	3.7	38.8	54.3	15.2	275.1
30 kg N ha^{-1} (FYM) + 30 kg N ha^{-1}	88.2	30.7	33.2	3.3	34.3	48.1	13.0	230.8
15 kg N ha^{-1} (FYM) + 45 kg N ha^{-1}	85.9	30.7	33.0	3.4	35.1	49.3	13.2	236.9
15 kg N ha^{-1} (FYM) + 60 kg N ha^{-1}	91.5	30.4	32.4	3.6	36.9	52.5	14.4	262.9
LSD(p=0.05)	5.3	0.7	0.2	0.1	2.1	2.3	1.0	35.1

Table 2: Pearson correlation coefficient among yield PAR interception, LAI, Canopy temperature and soil temperature.

	PAR interception	LAI	Canopy temperature	Soil temperature
Baby corn yield	0.97115**	0.93707**	-0.88172**	-0.81553**
	<.0001	<.0001	0.0007	0.0040

** = Significant at 1 and 5% level of significance

Leaf area index

A perusal of data on leaf area index (Table 1) showed that LAI was maximum in N-P-K (75-15-11.3 kg ha^{-1}), which was statistically at par with 15 kg N ha^{-1}(FYM) + 60 kg N ha^{-1} and N-P-K (60-12-6 kg ha^{-1}). The increase in LAI, due to increased leaf area with increasing fertilizer levels was because of increased amount of cellular constituents, mainly protoplasm (Sheshagiri, 1998) and also due to the influence of phytochroms in promotion of cell division, cell enlargement, cell differentiation and cell multiplication resulting in consistent and statistically significant increase in total leaf area per plant and leaf area index (Rao and Padmaja, 1994).

The data pertaining to the dry matter accumulation (Table 1) revealed that maximum dry matter accumulation was recorded in N-P-K (75-15-11.3 kg ha^{-1}) which was statistically at par with 15 kg N ha^{-1} (FYM) + 60 kg N ha^{-1} and N-P-K (60-12-6 kg ha^{-1}) and minimum dry matter accumulation was observed in control plot. The increased dry matter production might be due to better utilization of nutrient and phased release of nutrients as per requirement of maize.

Baby corn yield and green fodder yield

The yield of baby corn was significantly affected by both inorganic and INM treatments. The maximum baby corn yield (15.2 q ha^{-1}) was recorded in treatment(N-P-K (75-15-11.3 kg ha^{-1}) which was statistically at par with treatments 15 kg N ha^{-1}(FYM) + 60 kg N ha^{-1}(through Urea) and N-P-K (60-12-6 kg ha^{-1}) and per cent increases in the yield over recommended dose of fertilizer (N 60 kg ha^{-1}) was 27.0, 20.2 and 18.7 respectively.

Similarly, maximum green fodder (275.0 q ha^{-1}) was recorded in N-P-K (75-15-11.3) kg ha^{-1}which was statistically at par with 15 kg N ha^{-1} (FYM) + 60 kg N ha^{-1} (through Urea) (262.9 q ha^{-1}), N-P-K (60-12-6) kg ha^{-1}(258.1 q ha^{-1}) and minimum green fodder yield was recorded in control. The per cent increase in the green fodder yield over recommended dose of fertilizer (N 60 kg ha^{-1}) in N-P-K (75-15-11.3 kg ha^{-1}), 15 kg N ha^{-1} (FYM) + 60 kg N ha^{-1} (through Urea) and N-P-K (60-12-6 kg ha^{-1}) treatments were 27.8, 24.0 and 20.6

respectively. These findings are in agreement with Luikham *et al.,* (2003).

Correlation study

Baby corn yield was highly dependent on PAR interception and leaf area index (Table 2). Baby corn yield significantly increased with increase in PAR and leaf area index. However increase in soil temperature and canopy temperature decreased the baby corn yield because of more stress imposed on plant significantly. Higher the soil temperature resulted in higher value of canopy temperature. With increase in leaf area index there was significant increase in the PAR inception because leaves are the main part of plant responsible for PAR interception. With increase in soil and canopy temperature there was lower leaf area index and PAR interception due to more stress imposed on plant.

CONCLUSION

Application of N-P-K (75-15-11.3 kg ha^{-1}), 15 kg N ha^{-1} (FYM) + 60 kg N ha^{-1} and N-P-K (60-12-6 kg ha^{-1}) significantly improved photosynthetically active radiation interception (PARI %), reduced soil and canopy temperature and increased baby corn productivity over recommended N application (N 60 kg ha^{-1})

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