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Supplemental Irrigation, Green Manuring and Nitrogen Levels on Growth Components, Dry-matter Accumulation and Physiological Parameters in Dryland Maize

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Field experiments were conducted during North East Monsoon season of 2002-03 and 2003-04 at Tamil Nadu Agricultural University, Coimbatore, to study the effect of supplemental irrigation, green manuring and nitrogen levels on growth, physiological parameters, dry matter accumulation and yield in dryland maize. Among supplemental irrigations, two supplemental irrigations given at tasseling and silking stages in 2002 and tasseling and soft dough stages in 2003 recorded significantly higher plant height at 90 DAS, dry matter production, crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), and grain yield of 1389 and 1784 kg ha^{-1} during 2002 and 2003 respectively followed by one supplemental irrigation at tasseling stage in both the years. Among green manures intercropping with sunnhemp and incorporation at 45 DAS recorded higher plant height, DMP, grain yield (1103 and 1506 kg ha^{-1} in 2002 and 2003 respectively). Application of 40 kg N ha^{-1} recorded significantly higher DMP and grain yield of 1169 and 1588 kg ha^{-1} during 2002 and 2003 respectively.

Key words: Maize, Supplemental irrigation, Green manuring, Moisture stress, N levels, Run off collection, Physiological parameters, Yield.

Maize is one of the major cereals cultivated in North - Western agro climatic zone of Tamil Nadu, of which 77% of the total cultivable area is under rain fed farming. Insufficient moisture during crop growth period coupled with inadequate nitrogenous fertilizer use either through organic or inorganic sources are major factors which limit the higher grain yield under rainfed farming. In recent years, much emphasis has been given to efficiently utilize the available rain water (i.e. harvesting and recycling of excess rainfall) and also use of organics to produce adequate amount of high quality food. Green manuring has been recognized as an efficient agronomic practice for stimulation of various biological properties of the soil leading to improved soil fertility and health (Pali, 2000). However information regarding these aspects are very meager in rainfed maize. Keeping these facts in mind, the present trial was undertaken to study the effect of maize on supplemental irrigation, green manuring and nitrogen levels on growth, physiological parameters and yield of maize.

Materials and Methods

The experiment was conducted at Tamil Nadu Agricultural University, Coimbatore during North East Monsoon season of 2002 and 2003 on clay loam soil with pH 8.4 and analyzing low in organic carbon (0.18%) and available N (140 kg ha^{-1}), medium in available P (19.36 kg ha^{-1}) and high in available K (365.2 kg ha^{-1}). The treatment combinations of 3 levels of supplemental irrigation in main plot (without, one and two supplemental irrigations) and in sub plot 3 intercropping system viz., sole crop of maize, maize + sunnhemp, maize + cowpea were allotted and in sub-sub plot 3 levels of N (0,20 and 40 kg ha^{-1}) were tested in split - split plot design replicated thrice. Two supplemental irrigations were given at tasseling and silking stage in 2002 and tasseling and grain filling stage in 2003. One supplemental irrigation was given at tasseling stage in both the years. Irrigation water was collected in 258m^3 farm pond. Seed rate of 20 kg ha^{-1} with a spacing of 45 X 20cm for maize. Cowpea var. CO.5 and sunnhemp var. CO1 were sown as a green manure crops simultaneously as per the treatment in between maize rows. Recommended dose of 40kg N ha^{-1} was applied in 2 splits as per the treatment. The irrigation was given through runoff recycling collected in farm pond and given in moisture stress at critical stage of the crop. The irrigation was given to a depth of 1 cm. The total rainfall received during the cropping period was 331 mm in 2002-03 and 315.8 mm in 2003-04.

Results and Discussion

Effect of supplemental irrigation on growth component and yield

Two supplemental irrigations given at moisture stress periods recorded significantly higher plant height during both the years followed by one

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supplemental irrigation given at tasseling stage during both the years. Similar trend was obtained for leaf area index, dry matter production, crop growth rate, relative growth rate and net assimilation rate.

Two supplemental irrigations recorded highest LAI and it was superior over others. The size of the leaf is determined by the number and size of the cell in the leaf and is influenced by the soil moisture which is well supplied under this treatment. The detrimental effect of soil moisture stress on LAI was reported by Singhania and Dhrendra, 2001.

The higher dry matter production in two supplemental irrigation (Table 1) was attributed to better plant growth with more number of leaves which resulted in higher dry-matter accumulation in leaves and stems at the initial stages (vegetative) and translocation to ear during later stages (reproductive). The results confirm the findings of patil et al., 2001.

Table 1. Growth parameters of dryland/maize influenced by supplemental irrigation, green manure intercropping and nitrogen levels.

Treatment	Plant height (cm) 90 DAS		Leaf area index-90 DAS		DMP (kg/ha) -90 DAS	
Supplemental irrigation	2002	2003	2002	2003	2002	2003
Without supplemental irrigation	167.3	170.1	5.10	5.14	5714	6210
One supplemental irrigation	169.1	172.2	5.35	5.45	6278	6772
Two supplemental irrigations	171.5	174.7	5.61	5.74	6921	7462
CD (p = 0.05)	1.6	1.2	0.04	0.04	193	186
Green manures Sole crop	168.4	171.3	5.31	5.40	5996	6501
Maize+sunnhemp	169.9	172.9	5.38	5.47	6547	7054
Maize+cowpea	169.6	172.8	5.37	5.47	6368	6891
CD (p = 0.05)	0.7	1.3	0.05	0.06	183	171
Nitrogen levels (kg/ha)	168.6	171.3	5.33	5.42	6006	6532
20	169.3	172.5	5.37	5.46	6291	6828
40	169.9	173.2	5.41	5.49	6616	7085
CD (P = 0.05)	0.9	0.8	0.03	0.04	110	119

Two supplemental irrigations recorded significantly higher CGR, RGR and NAR (Table 2). The increase in soil moisture, which inturn enhanced the nutrient availability and uptake of nutrients by maize. This is line with the work of Osmon *et al*., (1989).They found that moisture stress significantly reduced the CGR, RGR and NAR and vice versa in two supplemental treatments.

Significantly higher cob length, yield/plant /g and 100 seed weight, and grain yield (Table 3) were recorded in two supplemental irrigation treatment. This may be due to higher availablility of soil moisture under two supplemental irrigations which helped for normal cob development as a result of higher dry matter production and translocation of photosynthates from source to sink. The cumulative effect of all the processes, lead to increase in yield components as well as yield of maize. Letatulu *et al*., (1998) and Dilip Kumar and Ajiay Kumar (2001) also reported similar type of observations.

Effect of green manures on growth components and yield

Intercropping with sunnhemp and incorporation had significant influence on plant height which was on per with intercropping and incorporation of cowpea. The lowest plant height was recorded in sole crop.

Intercropping of sunhemp and incorporation recorded significantly higher dry mater production which was comparable with intercropping and incorporation of cowpea (Table 1). The higher DMP in intercropping and incorporation of sunhemp was attributed to increased availability of mineralized N and higher uptake of mineralized N by the crop from incorporated organic matter. Dasaraddy *et al*., 2001 observed that increase in nutrient supply was due to incorporation of green manures.

Growth analysis such as CGR, RGR and NAR was significantly higher(Table 2) in inter cropping with sunnhemp and incorporation which was on par with intercropping and incorporation of cowpea. This may be due to higher N uptake from mineralization of incorporated organic matter. There by increase in photosynthetic area which lead to enhanced photosynthetic rate and all the processes ultimately increased the overall growth.

Intercropping and Incorporation of sunnhemp recorded higher cob length, yield/plant, 100 seed weight, straw yield and grain yield (Table 3) which was comparable with intercropping and incorporation of cowpea. The added nutrients and organic carbon through incorporation of green manure to the soil enhanced higher availability of nutrients besides, improved physio-chemical and biological property

Table 2. Growth analysis of dryland/maize influenced by supplemental irrigation, green manure intercropping and nitrogen levels.

Treatment	Crop growth rate ($g/m^2/day$)		Relative growth rate (g/g/day)		Net assimilation rate (g/g/day)	
Supplemental irrigation	2003	2003	2003	2004	2003	2004
Without supplemental irrigation	9.01	9.00	0.0144	0.0149	0.0025	0.0031
One supplemental irrigation	9.85	9.85	0.0154	0.0158	0.0030	0.0035
Two supplemental irrigations	10.10	9.97	0.0157	0.0161	0.0035	0.0038
CD (p = 0.05)	0.23	0.10	0.0002	0.0002	0.0004	0.0002
Green manures Sole crop	9.21	9.21	0.0145	0.0150	0.0025	0.0031
Maize+sunnhemp	9.78	9.77	0.0154	0.0158	0.0036	0.0035
Maize+cowpea	9.74	9.74	0.0152	0.0156	0.0034	0.0034
CD (p = 0.05)	0.15	0.08	0.0002	0.0003	0.0002	0.0002
Nitrogen levels (kg/ha)	9.25	9.25	0.0144	0.0148	0.0026	0.0031
20	9.60	9.58	0.0151	0.0155	0.0028	0.0034
40	9.89	9.89	0.0157	0.0161	0.0030	0.0035
CD (P = 0.05)	0.13	0.06	0.0001	0.0002	0.0010	0.0001

of soil are the reasons for increase in yield component and there by yield of maize. This is in accordance with the findings of Behera *et al*. (1997) and Dasaraddy *et al*. (2001).

Effect of nitrogen on growth component and yield

Among nitrogen levels, 40 kg N ha^{-1} recorded significantly higher plant height. Similar trend was observed on LAI, DMP (Table 1). Under inadequate

Table 3. Yield components and yield of dryland/ maize influenced by supplemental irrigation, green manure intercropping and nitrogen levels.

Treatment	Cob length(cm)		Grain wt /pl (g)		100 seed wt (g)		Grain yield (kg/ha)	
Supplemental irrigation	2003	2004	2003	2004	2003	2004	2003	2004
Without supplemental irrigation	10.1	10.5	11.0	14.49	16.20	16.23	594	949
One supplemental irrigation	11.4	11.8	15.36	19.54	17.22	17.34	1023	1452
Two supplemental irrigations	12.4	13.1	19.05	22.70	18.05	18.20	1389	1784
CD (p = 0.05)	0.6	1.0	1.0	1.02	0.83	0.83	94	90
Green manures Sole crop	11.0	11.4	13.83	16.31	16.61	16.66	840	1229
Maize+sunnhemp	11.5	12.0	16.07	20.92	17.21	17.28	1103	1506
Maize+cowpea	11.5	12.0	15.54	20.64	17.11	17.16	1062	1450
CD (p = 0.05)	0.4	0.3	0.56	0.29	0.42	0.43	70	80
Nitrogen levels(kg/ha)	11.0	11.4	13.47	16.84	16.55	16.66	832	1183
20	11.3	11.8	15.10	19.02	17.01	17.06	1005	1413
40	11.6	12.2	16.87	22.0	17.37	17.38	1169	1588
CD (P = 0.05)	NS	0.2	0.56	0.24	0.25	0.25	63	85

supply of nitrogen during active vegetative growth stage, there will be accumulation of carbohydrates and as a result photosynthesis was decreased leading to lower dry matter production (Vadivel *et al*., 2001) and vice versa in higher N levels.

Higher CGR, RGR and NAR by application of 40 kg N ha^{-1} was due to the increased vegetative growth at early stage as a result of N supply and availability. Adequate available N in the soil due to higher N addition through fertilizer resulted in higher uptake of N by plants resulting in higher dry matter production, which ultimately increased cob length yield/plant, 100 seed weight and grain yield with N levels. This was observed by several workers (Narayanasamy *et al*., 1994 and Vadivel *et al*., 2001)

Seed crude protein

Highest seed crude protein content was recorded in two supplemental irrigations compared to one and without supplemental irrigation (Table 4). This was attributed to adequate soil moisture, nutrient uptake and assimilation of N, are the major constituent of protein.

Table 4. N uptake, seed crude protein content, proline content of dryland/ maize influenced by supplemental irrigation, green manure intercropping and nitrogen levels.

Treatment	N uptake (kg /ha)		Seed crude protein content (%)		Proline content (µg g fresh weight)	
Supplemental irrigation	2003	2004	2003	2004	2003	2004
Without supplemental irrigation	109.9	122.3	8.09	8.14	85.62	82.34
One supplemental irrigation	121.3	135.3	8.43	8.51	81.06	78.21
Two supplemental irrigations	129.1	144.1	8.91	9.01	77.27	75.08
CD (p = 0.05)	2.2	2.4	0.30	0.33	2.9	2.4
Green manures Sole crop	115.8	129.0	8.36	8.44	81.24	78.23
Maize+sunnhemp	122.5	136.6	8.62	8.73	83.34	81.04
Maize+cowpea	122.0	136.1	8.50	8.58	82.66	81.67
CD (p = 0.05)	1.0	1.1	0.21	0.25	NS	NS
Nitrogen levels(kg/ha)	114.3	127.2	8.45	8.51	82.36	79.26
20	120.4	134.2	8.68	8.76	84.19	81.38
40	125.6	140.3	8.82	8.92	83.73	83.51
CD (P=0.05)	1.8	2.0	0.19	0.21	NS	NS

Intercropping and incorporation of sunnhemp recorded higher crude protein. Because of narrow C:N ratio of leguminous plant, the release of N was higher through the mineralization process. Increased availability and uptake of N resulted in higher protein content.

Application of 40 kg N ha^{-1} was superior in increased seed crude protein content of maize, which was attributed to high availability of N to plants under higher N levels. Rajendran and Sundar singh, 1999 reported increase in seed crude protein of maize when N level was increased.

Proline content

Proline content was significantly influenced only by supplemental irrigation. The proline content recorded highest (Table 4) under rainfed crop without receiving any supplemental irrigation and lowest in two supplemental irrigations. In general, proline accumulation occurs during stress period. Hence proline content was lower in supplemental irrigation treatments. Kramer (1983) reported that proline content was increased under moisture stress period.

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