Indian J. Dryland Agric. Res. & Dev. 2014 29(1) : 85-88

# Utilization of Harvested Water for Protective Irrigation and Mulching with Integrated Nutrient Management to Mitigate Dryspell for Maize (*Zea mays* L.) Production under Dryland Conditions

**R. Hijam[1], G.N. Dhanapal[2] and S.P. Dineshkumar[2]**

[1]*Department of Agronomy, UAS, GKVK, Bangalore-560 065, Karnataka*
[2]*AICRP for Dryland Agriculture, UAS, GKVK, Bangalore-560 065, Karnataka*

Email: dhanapalgn@yahoo.com

**ABSTRACT:** In *kharif,* 2012 there was a drought condition in the eastern dry zone of Karnataka where the rainfall accounted for only about 59.5% of the normal rainfall. To assess the effect of protective irrigation and mulching to mitigate dryspell with integrated nutrient management in maize production, a field experiment was conducted at All India Co-ordinated Research Project for Dryland Agriculture, UAS, GKVK, Bangalore during *kharif,* 2012. The experiment was laid out in a split plot design and replicated thrice which consisted of three main treatments *viz.* $M_1$ (no protective irrigation and no mulch); $M_2$ (protective irrigation) and $M_3$ (protective irrigation with weed biomass mulching), and three sub-treatments *viz*. $N_1$ (recommended doses of fertilizers); $N_2$ (50% N substituted through poultry manure) and $N_3$ (50% N substituted through *Glyricidia* green leaf manuring) with recommended doses of $P_2O_5$ and $K_2O$ through fertilizers. Three protective irrigations of 246926 l/ha were given through harvested water collected in the farm pond. Significantly higher growth parameters, yield attributes, kernel yield (5424 kg/ha) and stover yield (10342 kg/ha) of maize was observed in the plots under protective irrigations and mulching. Among the nutrient management treatments, recommended dose of fertilizers gave significantly higher kernel (5628 kg/ha) and stover yield (9825 kg/ha).

**Key words:** *Glyricidia* green leaf manuring, harvested water, mulch, poultry manure, protective irrigation

Maize (*Zea mays* L.) is emerging as an important cereal crop after wheat and rice. It is one of the most important crops in dryland agriculture. Its special features like higher per day carbohydrate production, ability to suppress weeds and high adaptability to both rainfed and irrigated situations have favoured expansion of its area. Maize occupies around 8.33 m ha of land area in India with a production of 16.68 m t of which 76.5% is cultivated under rainfed conditions. In Karnataka, maize is grown over an area of 1.2 m ha with a production of 3.6 mt and productivity of 3000 kg/ha (Anon. 2012).

Semi-arid agro-ecosystems are characterized by erratic rainfall and higher evaporation rates leading to unreliable agricultural production. Mulching is one of the practices to conserve soil moisture. It is the practice of giving a protective covering usually of organic matter such as leaves, straw or peat, placed around the plants to prevent evaporation of moisture, the freezing of roots, and the growth of weeds. In drier arid and semi-arid regions, upto 50% of total evapo-transpiration from a crop can be lost through evaporation from the soil surface (Jalota and Arora, 2002).

Integrated use of plant nutrients is aimed at combined use of inorganic and organic sources of plant nutrients to improve efficiency of applied nutrients, reduce environmental hazards and improve crop productivity (Dilshad *et al.,* 2010). Protective irrigation along with proper nutrient management is an important strategy to minimize the yield gap between the rainfed and irrigated maize production systems. Hence, a field experiment was carried out to assess the effective utilization of harvested water for protective irrigation and mulching along with integrated nutrient management to mitigate dryspell and to maximize the maize production under dryland conditions.

## Materials and Methods

The field experiment was conducted during *kharif,* 2012 on a sandy loam soil low in available N (241.2 kg/ha) and $P_2O_5$ (19.8 kg/ha), and medium in available $K_2O$ (193.6 kg/ha) at AICRP for Dryland Agriculture, GKVK Bangalore. The experiment was laid out in a split plot design replicated thrice which consisted of three main treatments *viz.* $M_1$ (no protective irrigation and no mulches) which acts as the control; $M_2$ (protective irrigation) and $M_3$ (protective irrigation with weed biomass mulching) and three sub-treatments *viz*. $N_1$ (recommended doses of N, $P_2O_5$ and $K_2O$ @ 100:50:25 kg/ha through fertilizers); $N_2$ (50% N through poultry manure with recommended doses of $P_2O_5$ and $K_2O$) and $N_3$ (50% N through *Glyricidia* green leaf manuring with recommended doses of $P_2O_5$ and $K_2O$). The amount of $P_2O_5$ and $K_2O$ (each 50 and 25 kg/ha, respectively) was common in all the treatments. Maize hybrid, NAH-1137 (Hema) was sown @ seed rate of 15 kg/ha with a spacing of 60 cm x 30 cm on 27 July 2012 by dibbling. *Glyricidia* prunings (2.9% N) @ 3.75 t/ha (equivalent to 50% of the recommended N) were incorporated in $N_3$ plots one month before sowing and poultry manure (3% N) was incorporated in $N_2$ plots two weeks before sowing. The sources of N, $P_2O_5$, $K_2O$ in all the treatments were urea, single super phosphate and muriate of potash, respectively. Entire dose of $P_2O_5$, $K_2O$ and 50% N, as per treatment were applied at the time of sowing (27[th] July 2012), and the remaining 50% N was applied at 30 days after sowing (DAS). Three protective irrigations [21, 42 (vegetative stage) and 56 DAS (silking stage)] of 2.5 cm (4,44,444 l/ha) each were given in $M_2$ and $M_3$ plots through furrow and 13–14 t/ha of dry weed biomass was applied in each plot (27 $m^2$) between the rows of $M_3$ plots as mulch at 35 DAS. Plots were kept free from weeds by spraying atrazine @ 1.5kg a.i/ha (2 DAS) and hoeing (once at 30 DAS) to avoid crop-weed competition. All other agronomic practices were uniform for all treatments. The crop was experienced three dryspells *viz*. 10 days during 31 August to 09 September, 15 days during 12 September to 26 September and 17 days during 07 November to 23 November. The crop was harvested on 20 November 2012.

## Results and Discussion

### Effect of weather parameters on crop growth

The performance of maize was affected adversely due to inadequate soil moisture during September and October (deviation of rainfall from normal was -168.4 and -109.2 mm, respectively) and higher temperature (29.2 and 28.3$^o$C, respectively) during vegetative to silking stage (Table 1). To reduce further effect on vegetative and silking stage, two protective irrigation (7 and 21 September, 2012) to a depth of 2.5 cm were given. Sweeney and Marr (2005) opined that 2.5-5 cm depth of irrigation to pop-corn during silking stage increased the kernel yield by 60%.

### Growth parameters

The growth parameters at different growth stages and yield parameters of maize were significantly influenced by protective irrigation, mulching and integrated nutrient management. Among the main treatments, significantly taller plants, higher leaf area and higher dry matter production (115.8 cm, 3204.8 cm$^2$ and 308.9 g/plant, respectively) were observed in plots under protective irrigation + mulching ($M_3$) compared to protective irrigation alone ($M_2$) and control ($M_1$) at harvest (Table 2). Similar results were reported by Arora *et al.* (2011) and Girijesh *et al.* (2011). Recommended doses of fertilizers ($N_1$) gave higher plant height, leaf area and total dry matter at harvest (113.7 cm, 3147.1 cm$^2$ and 294.1 g/plant, respectively) among the sub-treatments followed by 50% of recommended N through poultry manure + 50% N through fertilizers + recommended doses of $P_2O_5$ and $K_2O$ through fertilizers ($N_2$) and 50% N through *Glyricidia* leaf manuring + 50% N through fertilizers + recommended doses of $P_2O_5$ and $K_2O$ through fertilizers ($N_3$). Balai *et al.* (2011) and Sharma and Banik (2012) also reported similar results with use of recommended doses of fertilizers. Higher plant height (131.9 cm) and leaf area (3570.6 cm$^2$) at harvest were observed in plots under protective irrigation with mulch and recommended doses of fertilizers ($M_3N_1$) treatment combination. Available moisture might be higher due to protective irrigation and mulch which reduced the evaporation from the soil leading to higher plant height and leaf area. These results are conformed with the findings of Mitra and Bhattacharya, (2005) who reported that mulching of weed biomass @ 5 t/ha increased the growth parameters of green gram.

### Crop yield

Significantly higher kernel and stover yields of maize (5424 kg/ha and 10342 kg/ha) were recorded in plots under protective irrigation + mulches ($M_3$) compared to protective irrigation ($M_2$) and control ($M_1$) (Table 2). It was due to higher moisture availability to the root zone resulting in better mineralization of the plant nutrients present in the soil (Sharma and Banik, 2012). Similar results were reported by Lakshmi and Balasubramanian (2009), and Girijesh *et al.* (2011) who reported that higher kernel and straw yields of maize were obtained by providing two supplemental irrigation at the silking and dough stage.

Among the nutrient management treatments, recommended doses of fertilizers ($N_1$) gave significantly higher kernel and stover yields (5628 kg/ha and 9825 kg/ha) compared to 50% N through poultry manure + 50% N through fertilizers + recommended doses of $P_2O_5$ and $K_2O$ through fertilizers ($N_2$) and 50% N through *Glyricidia* leaf manuring + 50% N through fertilizers + recommended dose of $P_2O_5$ and $K_2O$ through fertilizers ($N_3$) (Table 2). Nutrients supplied through fertilizers are readily available form to the plants and this lead to the better growth and development of the maize. Jat *et al.* (2013) also reported similar results with use of recommended doses of fertilizers. Higher kernel and stover yields (6498 kg/ha and 11195 kg/ha) were recorded in plots under protective irrigation with mulch and recommended doses of fertilizers ($M_3N_1$).

### Economics

The cost of cultivation of maize was higher (₹ 21,989/ha) with protective irrigation with mulch and integration of *Glyricidia* leaf manuring ($M_3N_3$) because of higher labour cost (₹ 150/day/labour) incurred in incorporation of *Glyricidia* leaf manuring, followed by (₹ 20,065/ha) protective irrigation with mulch and integration of poultry manure ($M_3N_2$) and lowest (₹ 17,965/ha) in no protective irrigation with no mulches and recommended doses of fertilizers ($M_1N_1$).

Higher net returns and benefit-cost ratio (₹ 73,124/ha and 3.6) were realized with protective irrigation + mulch and recommended doses of fertilizers followed by protective irrigation and recommended doses of fertilizers (₹ 65,636/ha and 3.5) (Table 3). Similar results were reported by Dhanapal and Ravikumar (2012).

## Conclusion

Protective irrigation with mulching could effectively mitigate dry spell. Protective irrigation during the critical crop growth stages like siliking and garin filling stage increased kernel and stover yields each by 27% over control plots. Application of recommended doses of fertilizers proved to be more beneficial and gave 19.5 and 27.5% higher kernel and stover yields of maize over integrated nutrient management with poultry manure and *Glyricidia* leaf manuring, respectively.

**Table 1 : Normal (1976-2011) and actual monthly weather data during *kharif* season 2012 at GKVK, Bangalore**

| Month | Rainfall (mm) | | | Relative humidity (%) | | | Mean daily air temperature (°C) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Maximum | | | Minimum | | |
| | N | A | D | N | A | D | N | A | D | N | A | D |
| July | 116.2 | 97.2 | -19 | 72.5 | 72 | -0.5 | 28.3 | 28.7 | 0.4 | 19.4 | 19.6 | 0.2 |
| August | 134.2 | 100.1 | -34.1 | 73.1 | 73 | -0.1 | 27.6 | 28.3 | 0.7 | 18.8 | 19.3 | 0.5 |
| September | 197.6 | 29.2 | -168.4 | 72.9 | 71.5 | -1.4 | 28.1 | 29.2 | 1.1 | 18.8 | 19.4 | 0.6 |
| October | 173.9 | 71 | -102.9 | 72 | 71.5 | -0.5 | 27.7 | 28.3 | 0.6 | 18.2 | 18.7 | 0.5 |
| November | 53.3 | 150 | 96.7 | 72.3 | 70.5 | -1.8 | 26.6 | 27.2 | 0.6 | 16.6 | 16.2 | -0.4 |
| Total/mean | 675.2 | 447.5 | -227.7 | 72.6 | 71.7 | -0.9 | 27.7 | 28.3 | 0.7 | 18.4 | 18.4 | 0.0 |

N: Normal; A: Actual, D: Deviation

**Table 2 : Growth and yield of maize as influenced by protective irrigation, mulching and nutrient management**

| Treatment | Plant height (cm) | | | | Leaf area ($cm^2$) | | | | Kernel yield (kg/ha) | | | | Stover yield (kg/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $N_1$ | $N_2$ | $N_3$ | Mean | $N_1$ | $N_2$ | $N_3$ | Mean | $N_1$ | $N_2$ | $N_3$ | Mean | $N_1$ | $N_2$ | $N_3$ | Mean |
| $M_1$ | 91.1 | 79.7 | 76.2 | 82.2 | 2629.1 | 2285.3 | 2036.6 | 2317.0 | 4515 | 3879 | 3498 | 3964 | 8293 | 7602 | 6759 | 7752 |
| $M_2$ | 118.2 | 104.4 | 86.0 | 99.5 | 3241.7 | 2521.5 | 2245.8 | 2669.6 | 5870 | 4486 | 4185 | 4847 | 10087 | 9269 | 7289 | 8882 |
| $M_3$ | 131.9 | 120.0 | 95.6 | 115.8 | 3570.6 | 3510.9 | 2532.8 | 3204.8 | 6498 | 5227 | 4547 | 5424 | 11195 | 10045 | 9886 | 10342 |
| Mean | 113.7 | 101.4 | 82.4 | | 3147.1 | 2772.5 | 2271.9 | | 5628 | 4531 | 4077 | | 9858 | 8972 | 7978 | |
| For comparing the mean | SEm± | CD (P=0.05) | | CV (%) | SEm± | CD (P=0.05) | | CV (%) | SEm± | CD (P=0.05) | | CV (%) | SEm± | CD (P=0.05) | | CV (%) |
| Main (M) | 5.8 | 16.1 | | 12.4 | 80.0 | 222.0 | | 6.2 | 175 | 486 | | 8 | 404 | 1122 | | 10 |
| Sub (N) | 2.6 | 8 | | 7.8 | 84.5 | 260.2 | | 9.3 | 89 | 277 | | 6 | 186 | 574 | | 6 |
| Interaction (M x N) | 4.5 | 13.8 | | 7.8 | 146.3 | 450.7 | | 9.3 | 116 | 479 | | 6 | 323 | 994 | | 6 |

$M_1$: Control (no protective irrigation and mulches); $M_2$: Protective irrigation; $M_3$: Protective irrigation + mulches (Weed biomass mulch); $N_1$: Recommended doses of fertilizers through fertilizers; $N_2$: 50% N through poultry manure + 50% N through fertilizers; $N_3$: 50% N through *Glyricidia* leaf manuring + 50% N through fertilizers

**Table 3 : Economics of maize as influenced by different treatments**

| Treatment | Cost of cultivation (₹/ha) | Gross returns (₹/ha) | Net returns (₹/ha) | B:C ratio |
|---|---|---|---|---|
| $M_1N_1$ | 17965 | 64870 | 46905 | 2.6 |
| $M_1N_2$ | 18674 | 55830 | 37156 | 2.0 |
| $M_1N_3$ | 19889 | 50324 | 30435 | 1.5 |
| $M_2N_1$ | 18565 | 84201 | 65636 | 3.5 |
| $M_2N_2$ | 19274 | 64656 | 45382 | 2.4 |
| $M_2N_3$ | 18820 | 60055 | 41235 | 2.2 |
| $M_3N_1$ | 20065 | 93189 | 73124 | 3.6 |
| $M_3N_2$ | 20774 | 75194 | 54420 | 2.6 |
| $M_3N_3$ | 21989 | 65635 | 43646 | 2.0 |

$M_1N_1$**:** Control (no protective irrigation and mulches) + Recommended doses of fertilizers through fertilizers; $M_1N_2$: Control (no protective irrigation and mulches) + 50% N through poultry manure + 50% N through fertilizers; $M_1N_3$: Control (no protective irrigation and mulches) + $N_3$: 50% N through *Glyricidia* leaf manuring + 50% N through fertilizers; $M_2N_1$: Protective irrigation + Recommended doses of fertilizers through fertilizers; $M_2N_2$: Protective irrigation + 50% N through poultry manure + 50% N through fertilizers; $M_2N_3$: Protective irrigation + 50% N through *Glyricidia* leaf manuring + 50% N through fertilizers; $M_3N_1$: Protective irrigation + mulches (Weed biomass mulch) + Recommended doses of fertilizers through fertilizers; $M_3N_2$: Protective irrigation + mulches (Weed biomass mulch) + 50% N through poultry manure + 50% N through fertilizers; $M_3N_3$: Protective irrigation + mulches (Weed biomass mulch) + 50% N through *Glyricidia* leaf manuring + 50% N through fertilizers.

**Input cost:** Poultry manure (₹ 0.45/kg); Glyricidia (₹ 0.5/kg); Urea (₹ 5.3/kg); SSP (₹ 4/kg); MOP (₹ 4.8/kg); Zinc sulphate (₹ 26/kg); FYM (₹ 0.5/kg); *Azospirillum* inoculants (₹ 60/kg); Men labour (₹ 150/man day); Women (₹ 100/man day); Application of Glyricidia or Poultry manure (₹ 450/ton)

**Output price:** Maize grain (₹ 14/kg); Maize stover (₹ 0.2/kg)

## References


Anonymous. 2012. *http//:indiastat.com/2/agriculturalarea landuse / 152 /stats.aspx*

Arora VK, Singh CB, Sidhu AS and Thind SS. 2011. Irrigation, tillage and mulching effects on soybean yield and water productivity in relation to soil texture. Agricultural water management, 98: 563-568.

Balai ML, Verma A, Napalia V and Kanthaliya PC. 2011. Productivity and quality of maize (*Zea mays*) as influenced by integrated nutrient management under continuous cropping and fertilization. Indian Journal of Agricultural Sciences, 81(4): 374-376.

Dhanapal GN and Ravikumar HS. 2012. Effects of moisture conservation practices with protective irrigation and nutrient management on growth yield and economics of radish and to augment the water productivity in *Alfisols* in southern dry region of Karnataka. In: *Proceedings of Indian Water Week,* 10-14 April 2012, *New Delhi*. India. (In the Compact Disc).

Dilshad MD, Lone MI, Jilani G, Malik MA and Yousaf M. 2010. Integrated plant nutrient management (IPNM) on maize under rainfed condition. Pakistan Journal of Nutrition, 9(9): 896-901.

Girijesh GK, Kumaraswamy AS, Dineshkumar M, Nataraju SP, Vageesh TS and Rajashekarappa KS. 2011. Response of maize (*Zea mays*. L) to constraint irrigation under late sown conditions. Karnataka Journal of Agricultural Sciences, 24(5): 633-635.

Jalota SK and Arora VK. 2002. Model-based assessment of water balance components under different cropping systems in north-west India. Agricultural water management*,* 57: 75-87.

Jat SL, Parihar CM, Singh AK, Jat ML, Sinha AK, Mishra BN, Meena H, Paradkar VK, Singh CS, Singh D and Singh RN. 2013. Integrated nutrient management in Quality Protein Maize (*Zea mays*) planted in rotation with wheat (*Triticum aestivum*): Effect on productivity and nutrient use efficiency under different agro-ecological conditions. Indian Journal of Agricultural Sciences, 83(4): 391-396.

Lakshmi KV and Balasubramanian A. 2009. Supplemental irrigation, green manuring and nitrogen levels on growth components, dry-matter accumulation and physiological parameters in dryland maize. Madras Agricultural Journal, 96(7-12): 370-373.

Mitra S and Bhattacharya BK. 2005. Water use and productivity of green gram (*Vigna radiata*) as influenced by spacing, mulching and weed control under rainfed upland situation of Tripura. Indian Journal of Agricultural Sciences, 75(1): 52-54.

Sharma RC and Banik P. 2012. Effects of integrated nutrient management on baby corn-rice cropping system: economic yield, system production, nutrient-use efficiency and soil nutrient balance. Indian Journal of Agricultural Sciences*,* 82: 220-224.

Sweeney DW and Marr CW. 2005. Supplemental irrigation at reproductive stages to improve popcorn grown at different populations. Agronomy Journal, 97: 741-745.


Received: September 2013; Accepted: February 2014