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# Effect of Integrated Nutrient Management Practices on Growth and Development of Hybrid Maize Cultivar HQPM1 in Mid-Hills of Meghalaya

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## ABSTRACT

A field experiment was conducted during kharif 2011 on experimental farm of the College of Post Graduate Studies (CAU, Imphal), Umiam (Meghalaya) to evaluate the effect of integration of green manuring, FYM and fertilizers as integrated nutrient management (INM) practices on growth and developmental behaviour of quality protein maize cultivar QPM1. The data revealed that comparatively higher amount of primary nutrients were added in green manured maize plots in comparison to non green manured treatments. Green manuring also left a positive response on plant height, CGR, RGR leaf area, and dry matter accumulation in plants though the difference between green manured and non-green manured treatments was at par. Treatments 75 % RDF + 5 t FYM $ha^{-1}$, 50 % RDF + 7.5 t FYM $ha^{-1}$, 100 % RDF $ha^{-1}$ and 75 % RDF + 2.5 t FYM $ha^{-1}$ recorded significantly higher values of all the above said growth parameters over 50 % RDF + 5 t FYM $ha^{-1}$ and control treatments. At all stages of observations, the maximum dry matter was associated with RDF (recommended doses of fertilizers) which was at par with 75 % RDF + 5 t FYM $ha^{-1}$, but significantly higher over the plant dry weight recorded from all remaining treatments. A Significant difference in CGR at 30 – 60 and 60 – 90 DAS stage and in RGR at 90 DAS - harvest stage was observed due to various combinations of recommended dose of fertilizer with different doses of FYM. Number of days taken to attain the stages of 50% tasselling, silking and maturity did not differ significantly due to green manuring. However, treatment 75 % RDF + 5 t FYM $ha^{-1}$ took significantly lesser number of days for these stages than other treatment combinations. The superiority of the treatment 75 % RDF + 5 t FYM $ha^{-1}$ indicated a possibility of substituting 25% of RDF with 5 t FYM $ha^{-1}$ without any loss in dry matter accumulation in plants of the quality protein hybrid maize in mid-hill ecosystems of Meghalaya.

**Key words** : Integrated nutrient management, Green manuring, Plant height, CGR, RGR.

## INTRODUCTION

Maize (*Zea mays* L.) in North Eastern Hilly (NEH) region of India is the second most important food crop after rice. Besides a staple food for human beings, this crop is also a significant animal and poultry feed and has an enormous industrial importance for various uses. Maize accounts for 5 to 16 per cent of the daily calories of people in about 25 developing countries. Quality Protein Maize (QPM) has a specific feature of having high amino acids with higher content of lysine and tryptophan which makes it important for tackling against mal nutrition and having almost equal or better yield than the normal grain crop of maize (Prasanna *et al.,* 2001). This QPM will be especially helpful to combat protein mal nutrition in North-eastern hill regions of India where it is second important food crop after rice (Munda *et al.,* 2001). In NEH region of India maize productivity is below the national average as this crop is grown with very low or no external application of plant nutrients especially fertilizers even being a nutrient exhaustive crop. Farm yard manure (FYM) is common organic manure available with farmers in the region but in very limited quantity. In situ incorporation of a green manuring crop provides plant nutrients in better available form for a longer period for the associated cereal or for succeeding crops grown after green manuring. Since maize is a wide spaced crop grown at a spacing of 60 cm or more between two rows, it offers a good scope to grow at least one row of a fast growing, symbiotic N fixing legume like cowpea up to attaining its maximum vegetative growth (40-45 days after sowing) and then it's in situ incorporation for releasing its nutrients to take the advantage of green manuring to associated maize. Various earlier workers have reported that in-situ incorporation of green manure crops like cowpea, sunhemp, cluster bean etc., can add 40 to 120 kg N $ha^{-1}$ in soil for substituting crop nutrient requirements by cutting down a greater portion of nitrogen (N) needs of maize crop (Gangwar and Sharma, 1994; Dasareddy *et al.,* 2001 and Nooli *et al.,* 2001). A partial substitution of 25-50% of fertilizer doses by use of well decomposed farm yard manure (FYM) in maize and other nutrient exhausting crops has also been reported by various earlier workers (Das *et al.,* 2009; Kumar *et al.,* 2005; Kumar and Thakur, 2009; and Munda *et al.,* 2011). It has also been observed that no single source of plant nutrients whether organic or inorganic, can meet the entire nutrient needs of high nutrient demanding crops like maize. It emphasizes that

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all nutrient sources should be used in an integrated manner following a management technology that is appropriate, economically viable, socially acceptable, and ecologically sound (Finck, 1998). Thus, the present study was conducted to evaluate the influence of INM practices on growth and development behavior of a hybrid cultivar of quality protein maize HQPM 1.

## MATERIALS AND METHODS

A field experiment was conducted during Kharif 2011 at the experimental farm of College of Post Graduate Studies (CAU), Umiam, and Meghalaya. Amount of rainfall received during the crop season was 2,617 mm. Mean of the maximum and minimum temperature during the cropping season ranged from 31.4 °C and 16.4 °C, respectively while mean of relative humidity ranged from 89.28 % in the morning and 76.19 % in the evening hours. Mean bright sunshine hours and mean evaporation rate ranges from 2.84 to 4.10 h $d^{-1}$ and 2.10 to 2.35 mm $d^{-1}$, respectively while wind speed varied from 1.47 to 2.57 km $h^{-1}$ during the crop growing period. Soil of the experimental site was sandy loam in texture with bulk density of 1.36 g $cc^{-1}$, low in available N (250.85 kg $ha^{-1}$) and low in available K2O (106.43 kg $ha^{-1}$), medium in available P2O5 (20.62 kg $ha^{-1}$), high in organic carbon content (0.99 %) with moderately acidic reaction (pH 5.1). Experiment was conducted in split plot design (SPD) with three replications. Each replication was divided into two main plots for planting of sole maize (I0) and maize with cowpea green manuring (I1), randomly. Each main plot was further sub divided into six sub plots for adjusting various combinations of RDF and FYM viz., Control (F0), RDF (F1), 50 % RDF + 5.0 t FYM $ha^{-1}$ (F2), 50 % RDF + 7.5 t FYM $ha^{-1}$ (F3), 75 % RDF + 2.5 t FYM $ha^{-1}$ (F4) and 75 % RDF +5 t FYM $ha^{-1}$ (F5). The RDF for maize in mid hills of Meghalaya is 80-60-40 kg $ha^{-1}$ of N, phosphorus ($P_2O_5$) and potassium ($K^2O$), respectively. Fertilizer sources used for N, $P_2O_5$ and $K_2O$ were urea (46 % N), single super phosphate (16 % $P_2O_5$) and murate of potash (60 % $K_2O$). In control plots, maize was grown without the addition of any fertilizer or FYM dose. For in situ green manuring, one row of cowpea was grown in between two maize rows and incorporated in the soil at 45-46 days after sowing (DAS) with a spade.

Observations on various growth parameters from five randomly tagged plants in each plot was recorded at 30 days intervals starting from 30 days after sowing (DAS) till maturity except for leaf area which was recorded only up to 90 DAS by following the standard procedures. For recording dry matter accumulation in maize plants, the above ground portion was cut down from the base and then dried in air for 24-48 hours. Thereafter, samples were oven dried at 65 °C till a constant weight is obtained. Leaf area was recorded by taking the lengths of all the fully opened leaf lamina per plant from the base to the tip of the leaf. Breadth was taken at the widest point of the leaf lamina the products of length and breadth of the leaf was multiplied by the factor (f) to get the leaf area per plant. Number of days taken from sowing to tassel emergence, silk emergence and maturity was recorded when at least 50% of the plants in the four central rows within the net plot area was recorded as days taken to the stages of 50 % of taselling, silking and maturity. Data on biological yield ($tha^{-1}$) was recorded after one week of air drying of above ground dry matter from entire net plot at harvest.

Crop growth rate (CGR) was worked out by using following formula (Eq. 1):

$$CGR\ (mg\,cm^{-2}\,d^{-1}) = \frac{(W_2 - W_1)}{P \times (t_2 - t_1)} \times 1000 \quad \text{[Eq. 1]}$$

Where,

$W^1$ and $W^2$ = Dry matter production (g $plant^{-1}$) at time $t^1$ and $t^2$ respectively,

P = Ground area covered by an individual plant ($cm^2$).

Relative growth rate (RGR) was calculated by using the formula (Eq. 2):

$$RGR\ (mg\,g^{-1}\,d^{-1}) = \frac{(\mathrm{Log_e} W_2 - \mathrm{Log_e} W_1)}{t_2 - t_1} \times 1000 \quad \text{[Eq. 2]}$$

Where,

$W^1$ and $W^2$ = Dry matter production (g $plant^{-1}$) at time $t^1$ and $t^2$ respectively.

## RESULTS AND DISCUSSION

*Biomass and nutrient addition by green manure cowpea*

In present investigation, on mean basis, incorporation of cowpea added 39.4 to 54.39 q $ha^{-1}$ of fresh biomass and 6.23 to 8.26 q $ha^{-1}$ of dry biomass in different green manured treatments (Table 1). Minimum and maximum addition of both green and dry biomass of intercropped cowpea was observed in control and RDF treatments, respectively. The variation in addition of quantity of fresh and dry biomass in different plots was possibly the results of different levels of availability of nitrogen, phosphorus and potassium elements for growth and development of cowpea as per the subplot treatments. Differential addition of green manured cowpea dry matter in various treatments resulted in addition of varying amounts of primary nutrients ranging from 16.75 to 21.89 kg $ha^{-1}$ of N, 2.35 to 3.30 kg $ha^{-1}$ of P and 9.21 to 12.92 kg $ha^{-1}$ of K through cowpea in green manured treatments. Dasaraddy *et al.* (2001) as well as Kumar and Thakur (2009) also reported that addition of differential biomass and primary nutrients by cowpea in maize due to application of varying fertility levels in intercropped cowpea with maize.

**Table 1:** Biomass and nutrient addition by intercropped cowpea in green manured plots

| Treatments | Fresh weight (q $ha^{-1}$) | Dry weight (q $ha^{-1}$) | Nutrient Addition (kg $ha^{-1}$) | | |
|---|---|---|---|---|---|
| | | | Nitrogen | Phos-phorus | Potassium |
| Control | 39.4 | 6.23 | 16.75 | 2.62 | 9.21 |
| RDF | 54.39 | 8.26 | 21.89 | 3.30 | 12.92 |
| 50 % RDF + 5 t FYM | 43.37 | 6.72 | 18.28 | 2.35 | 9.22 |
| 50 % RDF + 7.5 t FYM | 44.51 | 7.22 | 19.62 | 2.53 | 9.22 |
| 75 % RDF + 2.5 t FYM | 47.78 | 7.49 | 20.45 | 3.00 | 10.21 |
| 75 % RDF + 5 t FYM | 50.2 | 7.76 | 21.56 | 2.95 | 10.58 |

**Growth and growth rates of HQPM 1**

Growth parameters such as plant height, leaf area and accumulation of dry matter per plant tend to increase with advancement of crop age and their maximum value was

recorded at last stage of observation. Plant height increased at faster rate up to 60 days (2.22 cm day$^{-1}$), thereafter, momentum decreased (1.38 cm day$^{-1}$) during 60-90 days and reached to its minimum during 90 days to harvest (0.184 cm day$^{-1}$). Plant height, leaf area and dry matter accumulation in plants did not vary significantly due to in situ incorporation of cowpea green manuring at any stage of crop growth however, green manuring increased the value of most of the growth parameters in maize as evidenced by relatively higher plant height, leaf area and dry matter especially during later stages of crop growth i.e. at 90 DAS and harvest stage over no green manuring treatments (Table 2 and 3). At 30 and 60 DAS stages, sole maize recorded slightly more dry matter over the treatments however, at 90 DAS and at harvest stage, green manured maize recorded 21 and 20.2 per cent more dry matter plant$^{-1}$, respectively, over sole maize. At harvest, green manured plots recorded 9.4 and 20.2 percent more of plant height and dry matter per plant over sole maize (Table 3). This enhanced growth response of maize under green manure incorporation was because of additional and continuous supply of N, P and K nutrients through rapid mineralization from easily decomposable cowpea biomass over the sole maize, throughout the crop growth period and possibly in addition to its positive effects on various soil physical and biological properties viz. reduced soil compaction, enhances aggregation of soil particles, enhanced microbial activities etc. for creating a favourable environment for better crop growth. Incorporation of green manuring had the beneficial effect on growth of maize in terms of plant height, leaf area and dry matter plant$^{-1}$ was also reported by Dasareddy *et al.* (2001), Nooli *et al.* (2001) and Kumar and Thakur (2009).

Significant variation in growth parameters at all the stages of observations was observed in present investigation due to application of various combinations of FYM with different levels of RDF. All the treatments received nutrients either as RDF or combinations of levels of RDF with different doses of FYM proved their significant superiority over control as proved by shortest plant with minimum dry weight at all the stages of observations. This poor growth in control plots was because of very less availability of essential elements especially N, P and K as it was solely depend on nutrient supplying capacity of the soil. At 30 and 60 DAS stages, highest growth in maize in terms of plant height, leaf area and dry matter per plant was recorded with the treatment RDF which was at par with 75 % RDF + 5 t FYM ha$^{-1}$ but significantly superior to rest of the treatments. This trend of growth might be due to more availability of N, P and K nutrients for crop uptake from inorganic fertilizers because of their greater solubility in soil solution at early stages of crop growth. However, at 90 DAS and at harvest stages, treatment 75 % RDF + 5 t FYM ha$^{-1}$ recorded highest value of these growth parameters as at later stages, some of the nutrients especially N and K in RDF plot was probably leached beyond root zone or lost as evaporation and run off or a part of orthophosphate ion got fixed with various forms of iron and aluminium in soil. On the other hands, mineralization of nutrients from FYM at later stages of crop growth in the treatments where it was combined with inorganic fertilizers enhanced the availability of N, P and K along with many other essential elements for crop plants and the nutrients were available throughout the active crop growing period. Besides, favourable physical and biological soil environment due to addition of organic matter from FYM, enhancing native soil nutrient availability through enhanced activity of microbial population and more use efficiency from fertilizer sources by reducing losses might be regarded as another reason for better plant growth under combined application of FYM with fertilizers at late stages of crop growth. At 90 DAS stage of observation, significantly highest leaf area was obtained from the treatment 75% RDF + 5 t FYM ha$^{-1}$. More number of leaves per plant with larger leaf size due to enhancement of cell division and cell expansion by assured supply of vital N in balance form with other nutrients during active crop growing period was probably responsible for this trend.

**Table 2**: Effect of integrated management practices on plant height and leaf area of HQPM 1 at various stages of crop growth

| Treatments | Plant height (cm) | | | | Leaf area (cm$^2$ plant$^{-1}$) | | |
|---|---|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | Harvest | 30 DAS | 60 DAS | 90 DAS |
| Sole Maize | 66.22 | 130.10 | 160.58 | 165.61 | 716.62 | 3412.76 | 3678.51 |
| Maize + Cowpea green manuring | 67.19 | 123.19 | 175.20 | 181.23 | 628.09 | 3713.07 | 3973.18 |
| SEm± | 1.12 | 3.41 | 3.53 | 3.00 | 20.10 | 108.53 | 60.14 |
| CD(P=0.05) | NS | NS | NS | NS | NS | NS | NS |
| Control | 54.68 | 94.16 | 138.57 | 144.95 | 504.42 | 2372.06 | 2797.07 |
| RDF | 74.36 | 139.82 | 173.48 | 179.77 | 818.02 | 4396.14 | 3956.82 |
| 50 % RDF + 5 t FYM | 64.71 | 122.74 | 165.61 | 170.13 | 620.76 | 3064.28 | 3611.64 |
| 50 % RDF + 7.5 t FYM | 67.95 | 128.82 | 175.87 | 180.97 | 632.62 | 3213.90 | 3994.59 |
| 75 % RDF + 2.5 t FYM | 64.04 | 130.01 | 168.60 | 173.63 | 707.66 | 4115.17 | 4054.00 |
| 75 % RDF + 5 t FYM | 74.49 | 144.32 | 185.22 | 191.15 | 750.63 | 4215.93 | 4540.94 |
| SEm± | 3.45 | 7.66 | 6.68 | 6.72 | 50.14 | 208.83 | 275.36 |
| CD(P=0.05) | NS | 22.58 | 19.71 | 19.81 | 147.90 | 616.06 | 812.31 |

**Table 3**: Effect of integrated management practices on dry matter production, CGR and RGR in maize cultivar HQM 1

| Treatments | Dry matter production (g plant$^{-1}$) | | | | CGR (mg$^{2}$cmday$^{-1}$) | | | RGR (mg g$^{-1}$ day$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | at Harvest | 30 - 60 DAS | 60-90 DAS | 90 DAS-harvest | 30 - 60 DAS | 60-90 DAS | 90 DAS-harvest |
| **Green manuring** | | | | | | | | | | |
| Sole Maize | 8.85 | 93.64 | 164.72 | 178.22 | 2.35 | 1.97 | 0.38 | 34.11 | 8.05 | 1.17 |
| Maize + Cowpea green manuring | 8.11 | 88.76 | 199.36 | 214.19 | 2.23 | 3.06 | 0.43 | 34.50 | 11.80 | 1.17 |
| SEm± | 0.19 | 2.04 | 7.85 | 8.05 | 0.06 | 0.29 | 0.01 | 0.62 | 0.92 | 0.06 |
| CD(P=0.05) | NS | NS | NS | N.S | NS | NS | NS | NS | NS | NS |
| **Fertilizer and FYM combination** | | | | | | | | | | |
| Control | 5.55 | 58.91 | 117.35 | 127.49 | 1.48 | 1.62 | 0.34 | 33.95 | 10.23 | 1.44 |
| RDF | 10.40 | 117.91 | 226.18 | 241.80 | 2.97 | 3.18 | 0.41 | 35.05 | 9.92 | 0.86 |
| 50 % RDF + 5 t FYM | 6.83 | 77.30 | 146.10 | 162.48 | 1.95 | 1.90 | 0.45 | 35.13 | 9.00 | 1.56 |
| 50 % RDF + 7.5 t FYM | 8.52 | 100.82 | 200.40 | 214.93 | 2.55 | 2.75 | 0.40 | 35.77 | 9.85 | 1.03 |
| 75 % RDF + 2.5 t FYM | 9.43 | 85.73 | 169.22 | 182.70 | 2.11 | 2.31 | 0.37 | 31.90 | 9.70 | 1.15 |
| 75 % RDF + 5 t FYM | 10.17 | 106.55 | 233.00 | 247.85 | 2.67 | 3.31 | 0.43 | 34.03 | 10.83 | 0.98 |
| SEm± | 0.26 | 5.47 | 8.24 | 8.19 | 0.15 | 0.23 | 0.04 | 1.05 | 1.07 | 0.13 |
| CD(P=0.05) | 0.78 | 16.14 | 24.30 | 24.16 | 0.45 | 0.69 | NS | NS | NS | 0.39 |

Accumulation of dry matter in plants also followed the trends similar to leaf area and leaf area index. Higher rate of dry matter in integrated organic and inorganic nutrients applied treatments was possibly due to more plant height, greater size of photosynthetic system as evidenced by leaf area and possibly higher rate of photosynthesis due to balanced availability of essential nutrients with favourable weather parameters. Kumar *et al.* (2005), Das *et al.* (2009), Kumar and Thakur (2009), Munda *et al.* (2011) and Shilpashree *et al.* (2012) also reported better growth and growth rates due to integrated application of FYM with various levels of recommended fertilizer levels over the control and fertilizers alone.

Green manuring had no significant influence on CGR of maize throughout its life cycle. However, significant variation in CGR was recorded due to various combinations of RDF with FYM between 30 – 60 DAS and 60 – 90 DAS where treatments 75 % RDF + 5 t FYM ha$^{-1}$ being at par with 100 % RDF recorded significantly more CGR over all other treatments. Since CGR is the change in rate of dry matter production per unit of land area with advancement of crop growth, higher dry matter production per plants in the plots treated with 75 % RDF + 5 t FYM ha$^{-1}$ and RDF was the reason for such significantly more CGR in them over other RDF – FYM combination treatments. During 90 DAS - harvest stage, treatment 50 % RDF + 5 t FYM ha$^{-1}$ recorded maximum RGR which being at par with control, was significantly superior over all other treatments. Since the treatments 75 % RDF + 5 t FYM ha$^{-1}$ and RDF marching towards maturity earlier than other treatments of various combinations of FYM and RDF, the rate of translocation of photosynthates was probably declined in their tissues due to faster drying of cell sap and this was the probable reason for significantly lower RGR in these treatment at last stage of crop. Nooli *et al.* (2001), Kumar *et al.* (2005) and Das *et al.* (2009) also observed similar behaviour of growth rates in maize due to integrated application of various organic and inorganic nutrient sources in maize.

**Table 4:** Effect of integrated management practices on days taken to attain the stages of 50 % of tasselling, silking and maturity.

| Treatments | Days taken to | | |
|---|---|---|---|
| | 50 % tasselling | 50 % silking | 50 % maturity |
| **Green manuring** | | | |
| Sole Maize | 67.67 | 78.61 | 96.22 |
| Maize + Cowpea green manuring | 67.28 | 77.06 | 95.72 |
| SEm± | 0.40 | 0.79 | 1.24 |
| CD(P=0.05) | NS | NS | NS |
| **Fertilizer and FYM combination** | | | |
| Control | 71.00 | 83.50 | 102.17 |
| RDF | 65.50 | 74.50 | 90.17 |
| 50 % RDF + 5 t FYM | 68.00 | 81.17 | 99.00 |
| 50 % RDF + 7.5 t FYM | 68.00 | 77.83 | 97.00 |
| 75 % RDF + 2.5 t FYM | 66.83 | 75.83 | 96.00 |
| 75 % RDF + 5 t FYM | 65.50 | 74.17 | 91.50 |
| SEm± | 0.95 | 1.81 | 1.87 |
| CD(P=0.05) | 2.79 | 5.34 | 5.52 |

**Attainment of developmental stages**

Days taken to attain the stages of 50% tasselling, silking and maturity did not differ due to green manuring however, all the plots receiving different doses of fertilizer and FYM took significantly less number of days to attain all these three stages (Table 4). Treatment without application of any nutrient (control) took maximum number of days to attain all these stages. Treatment 75 % RDF + 5 t FYM $ha^{-1}$ which was at par with RDF, took significantly less number of days to attain these stages in comparison to maize grown with 50 % RDF + 7.5 t FYM $ha^{-1}$ and control treatment plots (Table 4). Low availability of primary nutrients namely N, P and K in soil for plant absorption probably has slow down the growth rate in control plots was the possible reason for attaining all these developmental stages very late. Agarwal and Sekhon (1991) also observed advancement of phenological events like tasselling, silking and maturity in maize by integrated application of organic and inorganic sources for plant nutrient because of readily available plant nutrients in balance form along with favourable soil environment resulted in faster growth and development of crops.

## CONCLUSION

Growth, growth rates and attainment of various developmental stages in quality protein maize cultivar HQPM1 did not differ significantly due to green manuring of intercropped cowpea in maize even though relatively higher values of growth parameters were recorded from green manure plots especially at later stages of crop developments. However, growth and development behaviour of cultivar HQPM1 differed significantly at all the stages of observation, except for plant height at 30 DAS, due to application of various combinations of RDF with different doses of FYM.

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