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AGRONOMY

# Season wise analysis of productivity of maize hybrid COHM (5) with the influence of seed and crop management techniques

Srinivasan Jayaraman*[1], Srimathi P[2] and Vanitha Jayaraman[3]

[1]Department of Seed Science and Technology, APAC, TNAU, Vellore: 632506 , India
[2]Department of Seed Science and Technology, APAC, TNAU, Coimbatore-3, India
[3]Department of Plant Breeding and Genetics, TNAU, Coimbatore-3, India

Corresponding author: srinisst@gmail.com

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**Abstract**

The Studies were initiated to evaluate the influence of seed priming technique (15 per cent *Azospirillum* + 15 per cent phosphobacteria, 10per cent *P. fluorescens* + 20per cent Humic acid, 15 per cent *Azophos* + 10 per cent *P. fluorescens* and hydro priming technique) in conjunction with crop management techniques viz., nutrient supplementation as basal (humic acid @ 10kg ha$^{-1}$, micronutrient 5kg ha$^{-1}$) and foliar (diammonium phosphate 2 per cent, humic acid 0.1per cent, sea weed extract 0.5per cent) along with NPK application. The results revealed that seeds primed with 20 per cent humic acid + 10 per cent P. *flurescense*, applied with humic acid @ 10 kg ha$^{-1}$ as basal application and sprayed with 0.5% sea weed extract improved the productivity of maize and the grain recovery. On comparison of seed and crop management techniques the contribution of seed management technique was higher than crop management techniques. The evaluated seed and crop management techniques were further test verified at Bhavanisagar both during Kharif and Rabi season, which conformed the influence of identified seed and crop management techniques on enhanced productivity and nutrient status of the grain, recommending it as package for commercial hybrid production irrespective of season and location.

**Highlights**

- 20% humic acid + 10%P. *flurescense* priming gave best results
- Seaweed (0.5%)foliar spray, 10kg/ha humic acid + NPK gave best results
- Kharif season suitable for MaizeCOH(M)5.

**Keywords:** Maize, priming, humic acid, seaweed extract

Seed management techniques are the stimulatory action imposed in seed for improved expression as invigouration, protection and production. Among these, priming is proven to be a good invigouration technique (Rashid *et al*. 2006, Windauer *et al*. 2007, Afzal *et al*. 2008) that could be commercialized due to its encouraging advantages in wider variety of crops and its reproducibility (Murungu *et al*. 2004). Research on seed management techniques with biological inoculants is also warranted in organic farming, the newer vision of old wine in agriculture that emphasizes on soil and human health (www.fao.org). Among the bio products, humic acid (Amal, 2001, Olk *et al*. 2007), panchakavya (Natarajan 2002), biofertilizer (Hedge 2002) and biocontrol agents (Harman *et al*. 2004) are attracting the growers owing to their negligible negative effects and their coordinated relation with plant kingdom to its encouraging advantages in wider variety of crops and its reproducibility (Murungu *et al*. 2004).

There are many crop management techniques programmed for improved productivity.

Supplementation of NPK nutrients along with the basal or foliar application are source of the important management techniques practiced for productivity (Habtegebrial *et al*. 2007, Sekar, 2009, Ebelhar and varsa 2000). NPK nutrients are supplemented both by organic (Reddy and Ahmed 2009) and inorganic (Banaras *et al*. 2003) nutrients that are applied as basal application. The inorganic nutrient supplementation is majorly through application of micronutrients in small quantities either as individual compounds or as mixed nutrients, since these elements decide the success of the crop, as deficiency of any one of these nutrients lead to physiological disorder that in turn lead to loss of crop (Bose and Tripathi 1996). As Indian soils are deficit of micro nutrients, application of micro nutrient mixtures are recommended both by state government and the university (Anon 2012) as a general recommendation along with NPK fertilizers (Anon, 2005). The organic nutrients *viz*., vermicompost, coir pith, biofertilizer, FYM, humic acid, poultry manure etc., are also recommended for supplementation of nutrients along with NPK fertilizers. Among these, humic acid is the newly developing natural product rich in nutrients which is synthesised by the combustion of water, coal and organic matters (Bohme and Thilua 1997, Quaggiotti *et al*. 2004). Application of humic acid is found to be useful in seed (Revel *et al*. 1999), soil (Muscola *et al*. 1999) and crop management techniques, leading to improved productivity (Delfine *et al*. 2004). The organics like sea weed extract (Xavier and Jesudass 2007) and humic acid (Albayrak and Çamas 2005) are also recommended for increased seed set that enhance the productivity as per researchers, which would be highly helpful to organic growers.

Productivity of any genotype could be further streamlined in any given environment through implementation of advanced seed and crop management techniques (Chapman, 2008, Loffler *et al*. 2005). Hence attempts were made to have a comprehensive recommendation inclusive of seed and crop management techniques and seed storage techniques in newly released COHM(5) hybrid which is of commercial importance.

## Materials and methods

Genetically pure seeds of maize hybrid COH(M)5, obtained from Maize Research station, Vagarai, Palani constituted the base material for the study. The seeds were graded using 16 /64" round perforated metal sieve and were primed with water, 15 % *Azospirillum* + 15 % Phosphobacteria , 10 %*P. fluorescens* + 20 % Humic acid and 15 % Azophos + 10 % *P. fluorescens*, the biological products of liquid formulation in different concentrations adopting the standard seed to solution ratio of 1:1 as per the recommendations of crop production guide, Tamil Nadu (Anon, 2012) with the soaking durations of 8 h. Liquid azophos was obtained by mixing equal quantity of liquid Azospirillum and phosphobacteria. The liquid humic acid was obtained from Neyveli lignite corporation, Tamilnadu. The field trial was conducted at Agricultural Research Station, Bhavanisagar both during Kharif, and Rabi season under irrigated conditions . The crop was raised with seeds primed as above (four treatments) along with control seeds. Each of the individual priming treatments were combined with crop management techniques as supplementation of micronutrients in the form of humic acid @10kg ha$^{-1}$ (obtained from Neyveli lignite corporation in solid form ) micronutrient mixture @ 5kg ha $^{-1}$ (commercial product available as Agromin) that were applied with recommended NPK fertilizer @ 175:75:75 kg /ha **.**The crop grown with the above treatments were imposed with foliar application at tassel and silk initiation stages with 2 % Di Ammonium Phosphate( soild form soaked in water for over night and the supernatant solution was filtered for spraying), humic acid 0.1 % (liquid, formulation) and sea weed extract 0.5 % ( commercial liquid formulation ). The experimental design adopted was Factorial Randomised Block Design with three replication On sowing after 30 days with 4x100 seeds in each of the treatment and replication, the number of seedlings emerged were counted and the mean expressed in as field emergence percentage (%).The cobs were harvested at physiological maturity *i.e*., 105 days after sowing and five cobs in each of the treatments and replications were selected randomly and were dried under sun to bring the moisture to 15 per cent and the following observations were made on yield and yield attributing characters viz., cob weight plant$^{-1}$ (The cobs of the selected plants were weighted in a top pan balance and the mean expressed in gram), Grains cob$^{-1}$(seeds separated manually from each of the cobs of the selected individual plants and total number of grains in each of the cob were counted and mean expressed as whole number),kernel yield plant$^{-1}$ (The cobs of the selected plants were shelled separately and the grains were weighted in a top pan balance and the mean expressed in gram **)** and kernel /grain yield plot$^{-1}$ (The cobs of each of plot of all treatments and replications were threshed manually and weighed including the five plants selected for growth attributes and the mean expressed as kilograms ), which were computed to obtain grain yield in kilogram per hectare. The seeds of each of the treatment were nutrient uptake of grain for nitrogen, phosphorus and potassium as per Jackson, (1973).The data collected for the different characters were subjected to statistical analysis as per Panse and Sukhatme, (1967) for evaluating the critical differences among the traits at 5 per cent probability level. Whenever necessary, the per cent values were first transformed to analyzer (Arcsine) value before analysis

## Results and discussion

### *Influence of seed priming on growth parameters*

#### Influence of seed priming techniques on yield attributing parameters

Seed and crop management techniques evaluated for yield attributing parameters and nutrient uptake by grains at ARS, Bhavanisagar (11.478"N, 77.12"E) both during Kharif and Rabi season revealed that the seed treatments (T), nutrient supplementation both as basal (S) foliar (F) and their interactions significantly varied with the evaluated parameters (Table 1).

Crop productivity is the output of complex edaphic, environmental and management factors (Chapman 2008). The study initiated with the objective of evaluation on integrated influence of seed and crop management technique revealed that the seed treatments (T), nutrient supplementation both as basal (S) foliar (F) and their interactions significantly varied with the evaluated parameters (Table 1).

In Kharif season seeds primed (T) with 20 per cent humic acid + 10 per cent *P. fluorescens* recorded the maximum values for plant height (Table 1) at 90 DAS of plant growth (193.5 cm), while the lowest values were with unprimed seed (178.6 cm). The seeds primed with 20 per cent humic acid and 10 per cent *P. fluorescens* (mixed in 1:1 ratio) recorded maximum values for chlorophyll content (47.3), cob weight plant$^{-1}$ (105.2 g), kernel yield plant$^{-1}$ (66.2 g), grain recovery (82 %), kernel /grain yield plot$^{-1}$ (9.9 kg) and kernel /grain yield ha$^{-1}$(7573 kg) which was higher than unprimed seeds (178.6, 44.7, 101.8, 65.5, 64, 8.85, 6823). Tejada and Gonzales. (2006) also observed similar results in *Cyamopsis tetragonoloba* L. Taub and expressed the synergistic influence of *P.flurorescens* and humic acid as cause for the improved yield due to invigourative growth promotive action. Supplementation of the NPK nutrient with micro nutrient and humic acid expressed that application of humic acid @10kg ha$^{-1}$ had better influence on productivity than micronutrient applied @ 5 kg ha$^{-1}$. Baris *et al*. (2009) also expressed that soil application of humic acid (20 kg ha$^{-1}$) along with 100 per cent RDF improved the seed yield due to enhanced uptake of nutrients (David *et al*. 1994). Application of 0.5 per cent sea weed extract as foliar excelled the application of 0.5% humic acid and 2% DAP in improving the yield attributing characters and thereby the yield ,which recorded 6 and 4 per cent higher yield than 2 per cent DAP and 0.1 per cent humic acid respectively.

The interaction between seed treatment and foliar spray revealed that seed primed in 20 per cent humic acid + 10 per cent *P. fluorescens* and sprayed with seaweed extract (0.5 %) recorded the highest grain yield per plant and grain yield per ha (7465 kg), while the interaction between seed treatment and nutrient supplementation as basal application along with recommended NPK revealed that seed primed with humic acid (20 %) + *P. fluorescens* (10 %) and applied with humic acid @ (10kg/ha) as supplementary soil nutrient recorded the highest grain yield (7531 kg/ha). The interaction between seed treatment, basal nutrient supplementation and foliar spray revealed that seed priming with 10 per cent *P. fluorescens* + 20 per cent humic acid, supplemented with basal application with humic acid @ 10 kg ha$^{-1}$ along with NPK and sprayed with 0.5 per cent seaweed extract as foliar application improved the grain yield per plant and had a better grain yield ha$^{-1}$ (7864kg).

**Table 1:** Influence of seed and crop management techniques on productivity of maize hybrid COH(M)5 at kharif season

| Seed priming Techniques (T) A-Azospirillum P- phospho bacteria HA-Humic acid (Soaking duration – 8h and seed to solution ratio 1:1) | Crop Management Techniques | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Soil Nutrient Supplementation (S) along with NPK @ 175:75:75 Kg/ha( RDF) | | | | | | | | | | | Mean |
| | Micronutrient @ 5 Kg/ha | | | | Humic acid @ 10 Kg/ha | | | | TxF | | | |
| | Foliar sprays(F) | | | | | | | | | | | |
| | DAP 2% | Humic acid 0.1% | Sea weed extract 0.5% | Mean | DAP 2% | Humic acid 0.1% | Sea weed extract 0.5% | Mean | DAP 2% | Humic acid 0.1% | Sea weed extract 0.5% | |
| | Plant height cm (90 Days After Sowing) | | | | | | | | | | | |
| Unprimed | 168.6 | 177.8 | 184.1 | 176.8 | 172.4 | 181.3 | 187.6 | 180.4 | 170.5 | 179.6 | 185.9 | 178.6 |
| Hydropriming | 170.5 | 180.6 | 188.4 | 179.8 | 176.5 | 183.2 | 193.6 | 184.4 | 173.5 | 181.9 | 191.0 | 182.1 |
| 15%A+ 15% P | 173.4 | 185.5 | 191.2 | 183.4 | 180.5 | 187.6 | 197.4 | 188.5 | 177.0 | 186.6 | 194.3 | 185.9 |
| 20% HA + 10% P | 182.3 | 191.2 | 199.3 | 190.9 | 187.2 | 194.7 | 206.3 | 196.1 | 184.8 | 193.0 | 202.8 | 193.5 |
| 15%A +10 % *P* | 176.4 | 186.5 | 195.5 | 186.1 | 183.4 | 191.5 | 201.1 | 192.0 | 179.9 | 189.0 | 198.3 | 189.1 |
| Mean | 174.2 | 184.3 | 191.7 | 183.4 | 180.0 | 187.7 | 197.2 | 188.3 | 177.1 | 186.0 | 194.5 | 185.9 |
| Level of Significance | T | | F | S | | TxF | TxS | | SxF | | TxFxS | |
| SEd | 1.61 | | 1.15 | 0.96 | | 2.44 | 2.06 | | 1.63 | | 3.49 | |
| CD (P=0.05) | 3.22** | | 2.30** | 1.92* | | 4.89* | 4.12 * | | 3.27* | | 6.99* | |
| | chlorophyll content (per unit leaf area) (60 Days After Sowing) | | | | | | | | | | | |
| Unprimed | 44.2 | 44.5 | 44.9 | 44.5 | 44.4 | 44.7 | 45.3 | 44.8 | 44.3 | 44.6 | 45.1 | 44.7 |
| Hydropriming | 44.8 | 45.4 | 45.9 | 45.4 | 45.1 | 45.6 | 46.3 | 45.7 | 45.0 | 45.5 | 46.1 | 45.5 |
| 15%A+ 15% P | 45.2 | 45.9 | 46.5 | 45.9 | 45.6 | 46.4 | 46.8 | 46.3 | 45.4 | 46.2 | 46.7 | 46.1 |
| 20% HA + 10% P | 46.4 | 47.2 | 47.8 | 47.1 | 46.7 | 47.6 | 48.1 | 47.5 | 46.6 | 47.4 | 48.0 | 47.3 |
| 15%A +10 % *P* | 45.8 | 46.6 | 47.2 | 46.5 | 46.2 | 46.9 | 47.6 | 46.9 | 46.0 | 46.8 | 47.4 | 46.7 |
| Mean | 45.3 | 45.9 | 46.5 | 45.9 | 45.6 | 46.2 | 46.8 | 46.2 | 45.4 | 46.1 | 46.6 | 46.1 |
| Level of Significance | T | | F | | S | TxF | | TxS | | SxF | TxFxS | |
| SEd | 1.21 | | 0.95 | | 0.76 | 1.45 | | 1.46 | | 1.28 | 2.87 | |
| CD (P=0.05) | 2.42 ** | | 1.90* | | NS | 2.89* | | 2.92* | | NS | NS | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Cob weight plant$^{-1}$ (g) | | | | | | |
| Unprimed | 95.2 | 100.4 | 105.5 | 100.4 | 99.1 | 103.2 | 107.6 | 103.3 | 97.2 | 101.8 | 106.6 | 101.8 |
| Hydropriming | 96.7 | 101.4 | 106.6 | 101.6 | 101.1 | 105.4 | 110.7 | 105.7 | 98.9 | 103.4 | 108.7 | 103.7 |
| 15%A+ 15% P | 99.1 | 104.1 | 107.9 | 103.7 | 102.6 | 106.7 | 111.6 | 107 | 100.9 | 105.4 | 109.8 | 105.3 |
| 20% HA + 10% P | 102.1 | 107.2 | 110.5 | 106.6 | 105.2 | 109.5 | 112.7 | 109.1 | 103.7 | 108.4 | 111.6 | 107.9 |
| 15%A +10 % *P* | 100.4 | 105.4 | 109.2 | 105 | 103.1 | 108.1 | 112 | 107.7 | 101.8 | 106.8 | 110.6 | 106.4 |
| Mean | 98.7 | 103.7 | 107.9 | 103.4 | 102.2 | 106.6 | 110.9 | 106.6 | 100.5 | 105.1 | 109.4 | 105 |
| | T | | F | | S | | TxF | | TxS | SxF | | TxFxS |
| Sed | 1.77 | | 1.62 | | 1.12 | | 3.26 | | 2.77 | 2.41 | | 4.24 |
| CD (P=0.05) | 3.54** | | 3.24* | | 2.24 * | | 6.50* | | 5.54* | 2.48* | | 8.48* |
| | | | | | | Grain yield plant $^{-1}$(g) | | | | | | |
| Unprimed | 54.2 | 62.2 | 73.3 | 63.1 | 58.9 | 66.2 | 78.4 | 67.6 | 56.5 | 64.3 | 75.9 | 65.5 |
| Hydropriming | 58.1 | 66.0 | 74.5 | 66.1 | 61.9 | 69.8 | 83.8 | 71.6 | 60.1 | 67.9 | 79.1 | 69.0 |
| 15%A+ 15% P | 64.1 | 73.4 | 85.5 | 74.2 | 69.0 | 77.3 | 91.0 | 78.9 | 66.7 | 75.4 | 88.2 | 76.7 |
| 20% HA + 10% P | 74.5 | 85.8 | 96.9 | 85.5 | 82.6 | 90.1 | 102.0 | 91.5 | 78.7 | 87.9 | 99.6 | 88.6 |
| 15%A +10 % *P* | 69.8 | 78.1 | 89.6 | 79.0 | 72.3 | 82.7 | 95.7 | 83.4 | 71.0 | 80.5 | 92.8 | 81.3 |
| Mean | 64.1 | 73.1 | 84.0 | 73.6 | 68.9 | 77.2 | 90.2 | 78.6 | 66.6 | 75.2 | 87.1 | 76.2 |
| | T | | F | | S | TxF | | TxS | | SxF | TxFxS | |
| SEd | 1.23 | | 1.25 | | 0.82 | 2.27 | | 1.62 | | 1.48 | 4.15 | |
| CD (P=0.05) | 2.46** | | 1.50* | | 1.64 * | 4.54* | | 3.24* | | 3.96* | 8.30* | |
| | | | | | | Grain Recovery % | | | | | | |
| Unprimed | 57 | 62 | 69 | 63 | 59 | 64 | 73 | 65 | 58 | 63 | 71 | 64 |
| Hydropriming | 60 | 65 | 70 | 65 | 61 | 66 | 76 | 68 | 61 | 66 | 73 | 67 |
| 15%A+ 15% P | 65 | 71 | 79 | 72 | 67 | 72 | 82 | 74 | 66 | 72 | 80 | 73 |
| 20% HA + 10%P | 73 | 80 | 88 | 80 | 79 | 82 | 91 | 84 | 76 | 81 | 89 | 82 |
| 15%A +10 % *P* | 70 | 74 | 82 | 75 | 70 | 77 | 85 | 77 | 70 | 75 | 84 | 76 |
| Mean | 65 | 70 | 78 | 71 | 67 | 72 | 81 | 74 | 66 | 72 | 80 | 73 |
| Level of Significance | T | | F | | S | TxF | | TxS | | SxF | TxFxS | |
| SEd | 1.22 | | 1.03 | | 0.81 | 2.21 | | 1.63 | | 1.53 | 4.17 | |
| CD (P=0.05) | 2.44** | | 2.06* | | 1.62 * | 4.24* | | 3.26* | | 3.05* | 8.34* | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plot yield (kg) (2x 1.75 m) | | | | | | | | | | | | |
| Unprimed | 8.58 | 8.82 | 9.01 | 8.80 | 8.66 | 8.85 | 9.20 | 8.90 | 8.62 | 8.83 | 9.10 | 8.85 |
| Hydropriming | 8.88 | 9.14 | 9.41 | 9.14 | 9.04 | 9.29 | 9.58 | 9.30 | 8.96 | 9.21 | 9.50 | 9.22 |
| 15%A+ 15% P | 9.11 | 9.39 | 9.71 | 9.40 | 9.21 | 9.55 | 9.86 | 9.54 | 9.16 | 9.47 | 9.78 | 9.47 |
| 20% HA + 10%P | 9.37 | 9.82 | 10.20 | 9.80 | 9.62 | 9.98 | 10.42 | 10.01 | 9.50 | 9.90 | 10.31 | 9.90 |
| 15%A +10 % *P* | 9.15 | 9.56 | 9.96 | 9.55 | 9.33 | 9.80 | 10.16 | 9.76 | 9.24 | 9.68 | 10.06 | 9.66 |
| Mean | 9.02 | 9.34 | 9.66 | 9.34 | 9.17 | 9.49 | 9.84 | 9.50 | 9.10 | 9.42 | 9.75 | 9.42 |
| Level of Significance | T | | F | | S | | TxF | TxS | SxF | | TxFxS | |
| SEd | 0.12 | | 0.096 | | 0.072 | | 0.21 | 0.18 | 0.14 | | 0.30 | |
| CD (P=0.05) | 0.24** | | 0.19 ** | | 0.14* | | 0.42* | 0.34* | 0.27* | | 0.60* | |
| Grain yield per $ha^{-1}$ (Kg) | | | | | | | | | | | | |
| Unprimed | 6630 | 6797 | 6934 | 6787 | 6684 | 6821 | 7073 | 6859 | 6657 | 6809 | 7004 | 6823 |
| Hydropriming | 6842 | 7026 | 7224 | 7031 | 6956 | 7136 | 7345 | 7146 | 6899 | 7081 | 7285 | 7088 |
| 15%A+ 15% P | 7008 | 7209 | 7436 | 7218 | 7081 | 7322 | 7540 | 7314 | 7045 | 7266 | 7488 | 7266 |
| 20% HA + 10%P | 7195 | 7514 | 7786 | 7498 | 7372 | 7631 | 7942 | 7648 | 7284 | 7573 | 7864 | 7573 |
| 15%A +10 % *P* | 7034 | 7326 | 7612 | 7324 | 7165 | 7497 | 7756 | 7473 | 7100 | 7412 | 7684 | 7398 |
| Mean | 6942 | 7174 | 7398 | 7172 | 7052 | 7281 | 7531 | 7288 | 6997 | 7228 | 7465 | 7230 |
| Level of Significance | T | | F | | S | | TxF | TxS | | SxF | TxFxS | |
| SEd | 88.21 | | 68.33 | | 52.79 | | 152.79 | 124.75 | | 96.63 | 216.08 | |
| CD (P=0.05) | 176.60** | | 136.79** | | 103.69* | | 305.88 * | 249.75 * | | 193.45* | 429.16* | |

RDF (Recommended dose of fertilizer), * *significant at 1% level, *significant at 5% level

Thus the study on COH(M)5 maize hybrid revealed that primed seed (15 per cent *P. fluorescens* and 10 per cent humic acid ) received with humic acid (10 kg/ha) supplementation along with NPK followed with foliar application of sea weed extract (0.5 per cent) twice at tasseling and silk initiation stages rendered protective, invigourative and nutritive advantages and improved the productivity by improving the yield attributing characters.

**Season 2**

In Rabi season seeds primed (T) with 20 per cent humic acid + 10 per cent *P. fluorescens* recorded the maximum values for plant height (Table 2) at 90 DAS of plant growth (179.7 cm), while the lowest values were with unprimed seed (160.3 cm). The seeds primed with 20 per cent humic acid and 10 per cent *P. fluorescens* (mixed in 1:1 ratio) recorded maximum values for chlorophyll content (45), cob weight plant$^{-1}$ (105.2g), kernel yield plant$^{-1}$ (66.2 g), grain recovery (71 %), kernel /grain yield plot$^{-1}$ (6.45 kg) and kernel /grain yield ha$^{-1}$(7369 kg) which was higher than unprimed seeds (42, 98.9, 48.9, 55, 5.86, 6692). Tejada and Gonzales (2006) also observed similar results in *Cyamopsis tetragonoloba L. Taub* and expressed the synergistic influence of *P. fluroescens* and humic acid as cause for the improved yield due to invigourative growth promotive action. Supplementation of the NPK nutrient with micro nutrient and humic acid expressed that application of humic acid @10kg ha$^{-1}$ had better influence on productivity than micronutrient applied @ 5 kg ha$^{-1}$. Baris *et al*. (2009) also expressed that soil application of humic acid (20 kg ha$^{-1}$) along with 100 per cent RDF improved the seed yield due to enhanced uptake of nutrients (David *et al*. 1994). Application of 0.5 per cent sea weed extract as foliar excelled the application of 0.5% humic acid and 2% DAP in improving the yield attributing characters and thereby the yield ,which recorded 6 and 4 per cent higher yield than 2 per cent DAP and 0.1 per cent humic acid respectively.

The interaction between seed treatment and foliar spray revealed that seed primed in 20 per cent humic acid + 10 per cent *P. fluorescens* and sprayed with seaweed extract (0.5 %) recorded the highest grain yield per plant and grain yield per ha (7270 kg), while the interaction between seed treatment and nutrient supplementation as basal application along with recommended NPK revealed that seed primed with humic acid (20 %) + *P. fluorescens* (10 %) and applied with humic acid @ (10kg/ha) as supplementary soil nutrient recorded the highest grain yield (7105 kg/ha). The interaction between seed treatment, basal nutrient supplementation and foliar spray revealed that seed priming with 10 per cent *P. fluorescens* + 20 per cent humic acid, supplemented with basal application with humic acid @ 10 kg ha$^{-1}$ along with NPK and sprayed with 0.5 per cent seaweed extract as foliar application improved the grain yield per plant and had a better grain yield ha$^{-1}$ (7675kg). Thus the study on COH(M)5 maize hybrid revealed that primed seed (15 per cent *P. fluorescens* and 10 per cent humic acid ) received with humic acid (10 kg/ha) supplementation along with NPK followed with foliar application of sea weed extract (0.5 per cent) twice at tasseling and silk initiation stages rendered protective, invigourative and nutritive advantages and improved the productivity by improving the yield attributing characters.

***Influence of season on seed and crop management techniques and its productivity***

**Influence of seed and crop management techniques on productivity**

Crop productivity is the product of G x E (Genetic and Environmental) interaction but often application of seed (Zorita and Canigia 2009) and crop (Chen and Aviad 1990) management techniques have proven beneficial in enhancing productivity of crop (Luciano *et al*. 2002) and quality of the resultant produce. In the present study, three biopriming techniques conformed as best for their invigoration effect (15 per cent *Azospirillum* + 15 per cent phosphobacteria, 10 per cent *P. fluorescens* + 20 per cent humic acid, 15 per cent Azophos + 10 per cent *P. fluorescens*) along with hydro primed and unprimed seeds from previous experiment were evaluated for their productivity in conjunction with nutrient supplementation both as basal (humic acid @ 10 kg ha$^{-1}$, micronutrient 5 kg ha$^{-1}$) and as foliar (diammonium phosphate 2 per cent, humic acid 0.1per cent, sea weed extract 0.5 per cent). Any recommended package for crop production, inclusive of seed and crop management techniques could be recommended for adoption, when it is effective with different season and location. Hence the identified seed and crop management

**Table 2:** Influence of seed and crop management techniques on productivity of maize hybrid COH(M)5 at rabi season

| Seed priming Techniques (T) A-Azospirillum P- phospho bacteria HA-Humic acid (Soaking duration – 8h and seed to solution ratio 1:1) | Crop Management Techniques | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Soil Nutrient Supplementation (S) along with NPK @ 175:75:75 Kg/ha( RDF) | | | | | | | | | | | |
| | Micronutrient @ 5 Kg/ha | | | | Humic acid @ 10 Kg/ha | | | | TxF | | | |
| | Foliar sprays(F) | | | | | | | | | | | |
| | DAP 2% | Humic acid 0.1% | Sea weed extract 0.5% | Mean | DAP 2% | Humic acid 0.1% | Sea weed extract 0.5% | Mean | DAP 2% | Humic acid 0.1% | Sea weed extract 0.5% | Mean |
| Plant height cm (90 Days After Sowing) | | | | | | | | | | | | |
| Unprimed | 151.4 | 157.3 | 163.6 | 157.4 | 157.1 | 162.5 | 170.1 | 163.2 | 154.3 | 159.9 | 166.9 | 160.3 |
| Hydropriming | 158.4 | 161.1 | 167.8 | 162.4 | 164.7 | 171.2 | 174.2 | 170.0 | 161.6 | 166.2 | 171.0 | 166.2 |
| 15%A+ 15% P | 163.5 | 170.1 | 173.5 | 169.0 | 170.2 | 174.5 | 179.5 | 174.7 | 166.9 | 172.3 | 176.5 | 171.9 |
| 20% HA + 10%P | 174.2 | 177.2 | 180.3 | 177.2 | 175.6 | 180.3 | 190.5 | 182.1 | 174.9 | 178.8 | 185.4 | 179.7 |
| 15%A +10 % *P* | 170.2 | 173.2 | 178.6 | 174.0 | 175.2 | 176.4 | 184.2 | 178.6 | 172.7 | 174.8 | 181.4 | 176.3 |
| Mean | 163.5 | 167.8 | 172.8 | 168.0 | 168.6 | 173.0 | 179.7 | 173.7 | 166.1 | 170.4 | 176.2 | 170.9 |
| Level of Significance | T | | F | S | | TxF | TxS | | SxF | | TxFxS | |
| SEd | 1.42 | | 1.08 | 0.92 | | 2.47 | 1.95 | | 1.55 | | 3.36 | |
| CD (P=0.05) | 2.84** | | 2.16** | 1.85* | | 4.94* | 3.90* | | 3.10* | | 6.72* | |
| chlorophyll content (per unit leaf area) (60 Days After Sowing) | | | | | | | | | | | | |
| Unprimed | 40.5 | 41.6 | 42.8 | 41.6 | 41.2 | 42.2 | 43.4 | 42.3 | 40.9 | 41.9 | 43.1 | 42.0 |
| Hydropriming | 41.8 | 42.8 | 43.3 | 42.6 | 42.5 | 43.4 | 44.2 | 43.4 | 42.2 | 43.1 | 43.8 | 43.0 |
| 15%A+ 15% P | 42.3 | 43.6 | 44.2 | 43.4 | 42.8 | 44.1 | 45.2 | 44.0 | 42.6 | 43.9 | 44.7 | 43.7 |
| 20% HA + 10% P | 43.8 | 44.6 | 45.3 | 44.6 | 44.2 | 45.8 | 46.4 | 45.5 | 44.0 | 45.2 | 45.9 | 45.0 |
| 15%A +10 % *P* | 41.7 | 43.1 | 43.9 | 42.9 | 42.2 | 43.8 | 44.2 | 43.4 | 42.0 | 43.5 | 44.1 | 43.2 |
| Mean | 42.0 | 43.1 | 43.9 | 43.0 | 42.6 | 43.9 | 44.7 | 43.7 | 42.3 | 43.5 | 44.3 | 43.4 |
| | T | | F | | S | TxF | | TxS | | SxF | | TxFxS |
| Sed | 0.74 | | 0.93 | | 0.31 | 2.03 | | 1.66 | | 1.28 | | 2.87 |
| CD (P=0.05) | 1.48* | | 1.86* | | 0.62* | 4.05* | | 3.31* | | 2.56* | | 5.74* |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Cob weight plant$^{-1}$ (g) | | | | | | | |
| Unprimed | 94.8 | 96.9 | 102.3 | 98 | 95.8 | 98.8 | 104.9 | 99.8 | 95.3 | 97.9 | 103.6 | 98.9 |
| Hydropriming | 95.7 | 98.7 | 104.2 | 99.5 | 97.3 | 101.5 | 106.2 | 101.7 | 96.5 | 100.1 | 105.2 | 100.6 |
| 15%A+ 15% P | 98.6 | 100.8 | 105.6 | 101.7 | 99.7 | 102.9 | 108.5 | 103.7 | 99.2 | 101.9 | 107.1 | 102.7 |
| 20% HA + 10% P | 101.1 | 102.7 | 108.7 | 104.2 | 101.8 | 105.8 | 111.2 | 106.3 | 101.5 | 104.3 | 110 | 105.2 |
| 15%A +10 % *P* | 100.1 | 102.8 | 106.2 | 103 | 101.1 | 104.7 | 109.7 | 105.2 | 100.6 | 103.8 | 108 | 104.1 |
| Mean | 98.1 | 100.4 | 105.4 | 101.3 | 99.1 | 102.7 | 108.1 | 103.3 | 98.6 | 101.6 | 106.8 | 102.3 |
| | T | | F | | S | | TxF | | TxS | SxF | | TxFxS |
| Sed | 2.21 | | 1.97 | | 1.01 | | 3.75 | | 2.92 | 2.51 | | 5.97 |
| CD (P=0.05) | 4.42** | | 3.94* | | 2.02 * | | 7.70* | | 5.90* | 5.10* | | 11.96* |
| | | | | | Grain yield plant$^{-1}$(g) | | | | | | | |
| Unprimed | 43.9 | 47.7 | 51.6 | 47.7 | 46.6 | 50.8 | 53.3 | 50.2 | 45.2 | 49.3 | 52.5 | 48.9 |
| Hydropriming | 46.6 | 49.3 | 55.1 | 50.3 | 48.5 | 52.7 | 56.8 | 52.7 | 47.7 | 51.0 | 56.1 | 51.5 |
| 15%A+ 15% P | 51.6 | 56.1 | 62.5 | 56.8 | 54.5 | 60.1 | 64.9 | 59.8 | 53.1 | 58.2 | 63.8 | 58.2 |
| 20% HA + 10% P | 59.9 | 63.1 | 71.0 | 64.5 | 61.6 | 68.0 | 73.8 | 67.7 | 60.9 | 65.5 | 72.4 | 66.2 |
| 15%A +10 % *P* | 55.5 | 59.1 | 65.7 | 60.2 | 57.5 | 63.5 | 68.9 | 63.3 | 56.6 | 61.4 | 67.4 | 61.7 |
| Mean | 51.5 | 55.0 | 61.2 | 55.9 | 53.7 | 58.9 | 63.3 | 58.7 | 52.5 | 56.8 | 62.2 | 57.2 |
| | T | | F | | S | | TxF | | TxS | SxF | | TxFxS |
| SEd | 1.04 | | 0.95 | | 0.71 | | 1.89 | | 1.46 | 1.25 | | 3.43 |
| CD (P=0.05) | 2.08** | | 1.90* | | 1.42 * | | 3.78* | | 2.92* | 2.49* | | 6.86* |
| | | | | | Grain Recovery % | | | | | | | |
| Unprimed | 50 | 55 | 58 | 54 | 53 | 57 | 59 | 56 | 51 | 56 | 58 | 55 |
| Hydropriming | 53 | 58 | 62 | 58 | 55 | 60 | 64 | 60 | 54 | 59 | 63 | 59 |
| 15%A+ 15% P | 57 | 63 | 68 | 63 | 59 | 66 | 70 | 65 | 58 | 65 | 69 | 64 |
| 20% HA + 10% P | 62 | 68 | 74 | 68 | 66 | 71 | 81 | 73 | 64 | 70 | 77 | 71 |
| 15%A +10 % *P* | 59 | 65 | 71 | 65 | 63 | 68 | 73 | 68 | 61 | 66 | 72 | 66 |
| Mean | 56 | 62 | 66 | 62 | 59 | 64 | 69 | 64 | 58 | 63 | 68 | 63 |
| | T | | F | | S | | TxF | | TxS | SxF | | TxFxS |
| SEd | 1.22 | | 1.12 | | 0.84 | | 2.08 | | 1.62 | 1.43 | | 3.04 |
| CD (P=0.05) | 2.44** | | 2.24* | | 1.68 * | | 4.16* | | 3.24* | 2.86* | | 6.08* |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plot yield (kg) (2x 1.75 m) | | | | | | | | | | | | |
| Unprimed | 5.68 | 5.80 | 5.99 | 5.82 | 5.71 | 5.89 | 6.06 | 5.89 | 5.70 | 5.85 | 6.02 | 5.86 |
| Hydropriming | 5.80 | 6.00 | 6.16 | 5.99 | 5.88 | 6.05 | 6.22 | 6.05 | 5.84 | 6.02 | 6.19 | 6.02 |
| 15%A+ 15% P | 6.02 | 6.17 | 6.31 | 6.17 | 6.06 | 6.29 | 6.39 | 6.25 | 6.04 | 6.23 | 6.35 | 6.21 |
| 20% HA + 10%P | 6.19 | 6.33 | 6.62 | 6.38 | 6.25 | 6.49 | 6.82 | 6.52 | 6.22 | 6.41 | 6.72 | 6.45 |
| 15%A +10 % *P* | 6.10 | 6.25 | 6.45 | 6.27 | 6.17 | 6.36 | 6.60 | 6.38 | 6.14 | 6.31 | 6.53 | 6.32 |
| Mean | 5.96 | 6.11 | 6.31 | 6.12 | 6.02 | 6.22 | 6.42 | 6.22 | 5.99 | 6.16 | 6.36 | 6.17 |
| Level of Significance | T | | F | | S | | TxF | TxS | | SxF | TxFxS | |
| SEd | 0.09 | | 0.065 | | 0.037 | | 0.17 | 0.14 | | 0.11 | 0.24 | |
| CD (P=0.05) | 0.18** | | 0.12 ** | | 0.08* | | 0.34 * | 0.28 * | | 0.22 * | 0.48 * | |
| Grain yield per $ha^{-1}$ (Kg) | | | | | | | | | | | | |
| Unprimed | 6490 | 6627 | 6842 | 6653 | 6528 | 6737 | 6925 | 6730 | 6509 | 6682 | 6884 | 6692 |
| Hydropriming | 6630 | 6858 | 7042 | 6843 | 6724 | 6912 | 7104 | 6913 | 6677 | 6885 | 7073 | 6878 |
| 15%A+ 15% P | 6875 | 7051 | 7214 | 7047 | 6922 | 7193 | 7307 | 7141 | 6899 | 7122 | 7261 | 7094 |
| 20% HA + 10%P | 7070 | 7232 | 7561 | 7288 | 7145 | 7415 | 7789 | 7450 | 7108 | 7324 | 7675 | 7369 |
| 15%A +10 % *P* | 6971 | 7141 | 7372 | 7161 | 7056 | 7273 | 7543 | 7291 | 7014 | 7207 | 7458 | 7226 |
| Mean | 6807 | 6982 | 7206 | 6998 | 6875 | 7106 | 7334 | 7105 | 6841 | 7044 | 7270 | 7052 |
| Level of Significance | T | | F | | S | | TxF | TxS | | SxF | TxFxS | |
| SEd | 78.31 | | 62.25 | | 48.22 | | 141.37 | 112.32 | | 84.41 | 204.16 | |
| CD (P=0.05) | 154.61** | | 124.50** | | 98.44* | | 282.74 * | 224.64 * | | 168.82 * | 408.32* | |

RDF (Recommended dose of fertilizer), * *significant at 1% level, *significant at 5% level techniques evaluated for growth, yield and nutrient characters were test verified at Bhavanisagar (11.478″N, 77.12″E) both during Kharif and Rabi season (Table1&2). The crop was observed for the growth, yield and yield attributing characters as earlier. The seed and crop management technique identified as best at Bhavanisagar Kharif were again scored as best in both the seasons at Bhavanisagar as below which was better not only with control but also with hydroprimed seed.

The results indicated that hike in growth characters were more in control and was followed by hydropriming, while seed priming with Azophos + *P. fluorescens* almost on par with the selected biopriming technique, the10 per cent *P. fluorescens* + 20 per cent humic acid. While the yield attributing characters such as cob weight plant$^{-1}$, seed weight cob$^{-1}$, seed recovery, grain yield plot $^{-1}$ and grain yield ha$^{-1}$ recorded the highest values with seeds primed with 10 per cent *P. fluorescens* + 20 per cent humic acid followed by the Azophos + *P. fluorescens.* Comparison of the performance of scored treatment with other priming treatments, hydro priming and unprimed seed for yield attributing characters were as below.

### *Influence of seed biopriming technique*

The influence of pre sowing seed biopriming is said to extend upto productivity (Srimathi and Sujatha 2007). The crop was evaluated for their performance from vegetative to maturity phase for growth parameters (Plant height, number of leaf, leaf length, leaf breadth, chlorophyll content) the reproductive characters (flowering) and at harvest for yield attributing characters , yield and for the nutrient uptake by the grains, the resultant produce. Among the biopriming techniques, seeds primed with 20 per cent humic acid and value added with 10 per cent *P. fluorescens* recorded the highest values for plant growth characters (Table 3 and 4) at various stages of observation and the hike recorded by this treatment as percentage increase over the other treatments and unprimed

**Table 3:** Influence of seed priming on growth parameters

| Growth parameters | Influence of 20 % humic acid + 10 % P. fluorescens as percentage increase over other treatments (%) | | | |
|---|---|---|---|---|
| | Unprimed | Hydro priming | *Azosprillum* + phosphobactrerium | Azophos + *P.fluorescens* |
| Kharif | | | | |
| Plant height (cm) | 8.34 | 6.26 | 4.09 | 2.33 |
| Chlorophyll content | 7.11 | 5.3 | 3.07 | 1.39 |
| Rabi | | | | |
| Plant height (cm) | 12.1 | 8.12 | 4.54 | 1.93 |
| Chlorophyll content | 12.63 | 6.73 | 4.14 | 2.39 |

The comparison highlighted that the major yield attributing characters, the seeds per cob was 30 per cent higher than control and 22 per cent higher then their hydropriming and the plot yield was also 13 and 11 per cent higher than control and hydro priming respectively. Similar influence on yield and yield parameters were reported by Vidhyasekaran and Muthamilan (1995) and Vivekananthan (2000) due to the synergistic additive influence of both *P. fluorescens* and humic acid because of their growth regulatory function as detailed elsewhere on seed invigoration. Lakshmanan *et al*. (2005) evaluated the spermosphere (3 days old sprouted seeds) and rhizosphere population with three species and found that among the three bio products tested, the maximum spermosphere colonization was observed in rice seeds treated with *Azospirillum brasilense* SP-7 followed by *Azorhizobium caulinodans* ZB-SK-5 and *P. fluorescense* PF-1. In maize, sorghum, cumbu and ragi seeds, the maximum colonization was observed in *Azorhizobium caulinodans* ZB-SK-5 treated seeds. The rhizosphere population was maximum in *Azorhizobium* *caulinodans* ZB-SK-5 treated plants (Amutha *et al.* 2008). Hence the results of the present study might be due to the higher order of bacterial colonies with the combined applications bio products (10 per cent *P. fluorescens* + 20 per cent humic acid). Hence due to the action on plant protection and invigouration occurred due to the growth regulatory substances, seed priming with 10 per cent *P. fluorescens* + 20 per cent humic acid was effective in enhancing the productivity of crops.

**Table 4:** Influence of seed priming techniques on yield attributing parameters

| Growth parameters | **Influence of 20 % humic acid + 10 % *P .fluorescens* as percentage increase over other treatments (%)** | | | |
|---|---|---|---|---|
| | Unprimed | Hydro priming | Azosprillum + phospho bacteria | Azophos + *P. fluorescens* |
| Kharif | | | | |
| Cob length (cm) | 9.21 | 5.06 | 3.11 | 1.84 |
| Cob breadth (cm) | 7.30 | 5.76 | 3.52 | 1.38 |
| Grains cob$^{-1}$ | 29.23 | 25.37 | 14.81 | 11.01 |
| Cob weight plant$^{-1}$(g) | 5.99 | 4.05 | 2.47 | 1.41 |
| Grain yield plant $^{-1}$(g) | 35.27 | 28.41 | 15.51 | 8.98 |
| Grain recovery (%) | 28.13 | 22.39 | 12.33 | 7.89 |
| 100 seed weight | 3.61 | 3.61 | 2.14 | 1.06 |
| Grain yield plot (kg) | 11.86 | 7.38 | 4.54 | 2.48 |
| Yield ha$^{-1}$ (Kg) | 11.86 | 7.38 | 4.54 | 2.48 |
| Rabi | | | | |
| Cob length (cm) | 9.46 | 8 | 4.52 | 1.89 |
| Cob breadth (cm) | 6.67 | 5.11 | 2.86 | 1.41 |
| Grains cob$^{-1}$ | 29.09 | 22.63 | 12.02 | 5.43 |
| Cob weight plant$^{-1}$ (g) | 6.37 | 4.57 | 2.43 | 1.06 |
| Grain yield per plant (g) | 36.15 | 25.34 | 13.11 | 7.23 |
| Grain recovery (%) | 29.09 | 20.34 | 10.94 | 7.58 |
| 100 grain weight (g) | 4.06 | 2.92 | 1.44 | 0.71 |
| Grain yield plot $^{-1}$ (kg) | 10.13 | 7.11 | 3.92 | 2 |
| Yield ha$^{-1}$(kg) | 10.13 | 7.11 | 3.92 | 2 |

### *Influence of soil application*

The supplementation of the soil nutrient, through humic acid was found to be better than micronutrient application recommended as per crop production guide (Anon 2005) of Tamil Nadu and the evaluated parameters expressed that application of humic acid @10kg ha$^{-1}$had better influence than micronutrient applied @ 5 kg ha$^{-1}$ which had 1.59 per cent hike in plant height irrespective of the stages of observation. Within the stages, the efficacies of the leaf characters were effective only at 60 days (flowering phase). Similarly the influence of chlorophyll content was also higher and effective at vegetative phase alone and was unaltered with further changes in growth. Among the yield parameters, the cob measurements and 100 grain weight (Table 5) were not influenced by soil nutrient supplementation, while the influence of other significant parameters compared to micronutrient application

**Table 5:** Influence of soil nutrient supplementation on growth and yield characters. (Influence of soil nutrient supplementation of humic acid as percentage increase over micronutrient application.)

| Growth parameters | Bhavanisagar Kharif | Bhavanisagar Rabi |
|---|---|---|
| Plant height (cm) | 2.67 | 3.39 |
| Chlorophyll content | 0.95 | NS |
| **Yield parameters** | | |
| Cob length (cm) | 2.53 | NS |
| Cob breadth (cm) | NS | NS |
| Grains cob$^{-1}$ | 6.37 | NS |
| Cob yield per plant (g) | 3.95 | 1.97 |
| Grain yield per plant (g) | 6.8 | 6.41 |
| Grain recovery (%) | 4.22 | 3.22 |
| 100 seed weight (g) | 1.75 | NS |
| Grain yield plot$^{-1}$ (kg) | 1.71 | 1.43 |
| Yield ha$^{-1}$ (kg) | 1.71 | 1.43 |

### *Influence of foliar spray*

Foliar spray is the application of needy nutrients at reproductive phase through foliage to have direct impact on seed set and its resultant nutrient quality. Irrespective of other factors, the results revealed that application of 0.5 per cent sea weed extract excelled the application of humic acid and diammonium phosphate both with growth and yield characters. All growth parameters expressed hike in percentage from tasseling to maturation phase. Within the foliar sprays, sea weed extract recorded 5.4, 4.9, 10.7 and 3.07 per cent hike for plant height, leaf length, leaf breadth and chlorophyll content at flowering phase (immediately after spray) compared to DAP 2 per cent spray, the commonly recommended foliar nutrient (Anon 2005) for enhance seed set. At maturation phase also similar hike better than the flowering phase (5.59, 7.71, 12.35 and 6.01 per cent) was evident for all growth parameters *viz*., plant height, leaf length, leaf breadth and chlorophyll content (Table 6). Foliar spray with humic acid also recorded similar improvement in yield characters and nutrient uptake

**Table 6:** Influence of foliar nutrition (Influence of sea weed extract foliar nutrition of humic acid as percentage increase over micronutrient application).

| Growth parameters | Influence of Sea weed extract 0.5% as percentage increase over humic acid 0.1 % and diammonium phosphate 2% | | | |
|---|---|---|---|---|
| | Bhavanisagar (Kharif ) | | Bhavanisagar (Rabi ) | |
| | DAP 2% | HA 0.1% | DAP 2% | HA 0.1% |
| Plant height (cm) | 9.82 | 4.57 | 6.08 | 3.40 |
| Chlorophyll content | 4.60 | 1.89 | 7.91 | 3.68 |
| **Yield and yield attributing characters** | | | | |
| Cob length (cm) | 8.50 | 3.75 | 5.30 | 3.25 |
| Cob breadth (cm) | 5.04 | 3.55 | 3.65 | 1.43 |
| Grains cob$^{-1}$ | 17.87 | 8.94 | 22.97 | 9.90 |
| Single cob weight (g) | 8.86 | 4.09 | 8.32 | 5.12 |
| Grain yield per plant (g) | 30.78 | 15.82 | 27.64 | 13.28 |
| Grain recovery (%) | 21.21 | 11.11 | 17.24 | 7.94 |
| 100 seed weight (g) | 3.62 | 2.14 | 2.56 | 1.08 |
| Grain yield per plot (kg) | 7.14 | 3.50 | 6.17 | 3.15 |
| Yield ha$^{-1}$ (kg) | 6.69 | 3.28 | 6.27 | 3.21 |

But the hike ranged from 3.50 to 15.82 per cent expressing the efficacy of humic acid that could be recommended next to sea weed extract. Even in yield parameters, the hike was lesser with humic acid and more with DAP spray. However, the yield recorded by sea weed extract was 6.1 and 4.0 per cent higher than 2 per cent DAP and 0.1 per cent humic acid respectively.

Among the foliar sprays, seaweed extract excelled others, which might be due to higher content of potash (Naganathan *et al.* 2008) and carbohydrates (Anitha *et al.* 2008) and amino acids (Nedumaran *et al.* 2008). Sea weed extract is also being recommended as liquid fertilizer and is said to contain macro and micro nutrients (Naganathan *et al.* 2008), growth promoting hormones (Arumugam *et al.* 2008) cytokinin (Mooney and Staden 1986) and gibberellins (Kannathasan *et al.* 2008). The efficacy of DAP and humic acid was also evidenced by Annadurai and Palaniappan (1995) and Delfine *et al.* (2005) due to increase in nutrient uptake (Elayaraja and Angayarkanni 2005) and physiological stamina. Thus the study expressed that foliar application of sea weed extract followed by humic acid and DAP could be recommended for higher productivity.

**Individual and interactive effect of seed and crop management techniques at Bhavanisagar on grain recovery and yield**

Thus the study irrespective of season or location recommended the following crop production package for enhanced productivity of maize COH (M) 5 as earlier observed with coimbatore crop and in each of the crop and as cumulative effect, the influence of seed treatment was the highest and was followed by foliar spray and soil nutrient supplementation (Table 7).

**Table 7:** Individual and interactive effect of seed and crop management techniques at Bhavanisagar on grain recovery and yield

| Influence of Individual effect of seed and crop management techniques | | | Influence of two factors in seed and crop management techniques | | | Influence of three factors in seed and crop management techniques | | |
|---|---|---|---|---|---|---|---|---|
| **Kharif** | | | | | | | | |
| | **Grain recovery (%)** | **Grain yield per ha (kg)** | | **Grain recovery (%)** | **Grain yield per ha (kg)** | | **Grain recovery (%)** | **Grain yield per ha (kg)** |
| Seed treatment 10% *P.fluorescens* and 20%humic acid | 82 | 7573 | T x F | 89 | 7824 | T x S x F | 91 | 7942 |
| Foliar spray with sea weed extract (0.5 per cent). | 80 | 7465 | T x S | 84 | 7648 | | | |
| Soil application of humic acid along with NPK | 74 | 7288 | S x F | 81 | 7531 | | | |
| **Rabi** | | | | | | | | |
| Seed treatment 20% *P.fluorescens* + 20% humic acid | 71 | 7369 | T x F | 77 | 7675 | T x S x F | 81 | 7789 |
| Foliar spray with sea weed extract (0.5 per cent). | 68 | 7270 | T x S | 73 | 7450 | | | |
| Soil application of humic acid along with NPK | 64 | 7105 | S x F | 69 | 7334 | | | |

Hence seed priming with 10 per cent *P. fluorescens* + 20 per cent humic acid and the basal application with humic acid @ 10 kg ha$^{-1}$ along with NPK and foliar application of 0.5 per cent sea weed extract, could be recommended as package which improved the productivity of maize COH(M) 5 as 7832 Kg ha$^{-1}$ irrespective of the season and location. Sumathi (2010) also observed variation in yield attributing characters and yield with season and location due to climatic variation and soil fertility.

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