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Quality cutting production of chrysanthemum (*Dendranthema grandiflora*) as influenced by integrated nutrient management of the plants during production phase

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ABSTRACT

This investigation was conducted at the Research Farm of Department of Floriculture and Landscaping, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh during the year 2010 and 2011 to ascertain the rooting behavior of cuttings taken from two chrysanthemum (*Dendranthema grandiflora*) cultivars Purnima and Ajay as affected by integrated nutrient management during the production phase of the plants. Plants grown under open field condition were subjected to 17 different nutritional regimes in a factorial Randomized Block Design (RBD) replicated thrice. After flowering was over, plants were headed back. Regenerated cuttings from headed back plants were studied for various parameters. The results revealed that plants receiving treatment comprising of 22.5 g/m^2 each of NPK + Vermicompost (1 kg/m^2) + Biofertilizers (*Azotobacter* + PSB + VAM) produced the maximum number of cuttings/plant (36.45), length of the longest root (8.58 cm), number of roots/plant (28.95), highest rooting percentage (95.52 %) and maximum fresh weight of cuttings at harvest (3.79 g) and after rooting (3.89 g). The same treatment also took the least number of days (25.20 days) for rooting to occur. Plants treated with 15 g/m^2 each of NPK + Vermicompost (1 kg/m^2) + Biofertilizers recorded the highest nitrogen contents of cuttings at harvest (5.09 %) and after rooting (4.64 %). Among the cultivars, Purnima exhibited maximum number of cuttings/plant (37.86), lesser number of days for rooting (20.97) and maximum nitrogen contents of cuttings at harvest (4.16 %) and after rooting (4.47 %), whereas cultivar Ajay recorded the maximum length of the root (6.38 cm) and number of roots/plant (22.46).

Key words: Adventitious rooting, *Azotobacter*, Biofertilizers, Chrysanthemum, Cutting, NPK, PSB, VAM, Vermicomposts

Healthy planting material is one of the most important factors responsible for successful flower production in chrysanthemum (*Dendranthema grandiflora* Tzvelev). Besides, homogeneity of cuttings is also required as uniform, well grown cuttings offer uniformity and predictability in harvesting and flowering (Zerche *et al.* 1999). Commercially chrysanthemums are propagated by means of terminal shoot tip cuttings taken from stock plants. Physiological status of chrysanthemum cuttings during rooting process highly influences plant growth and flower production. The rooting capacity is influenced to a large extent by nutrition of the mother plant. Adventitious root formation of cuttings is substantially affected by the initial nitrogen and carbohydrate status of the cutting (Haissig 1986, Blazich 1988, Veierskov 1988). High nitrogen supply to the stock plants, meeting or even surpassing the level necessary for maximum growth, has often been observed to decrease subsequent rooting of cuttings (Roeber and Reuther 1982, Henry *et al.* 1992). Nugroho *et al.*, (2004) indicated that higher dry weight, more compact and faster rooting capacity of chrysanthemum was affected by fertilizer application during rooting process.

Several studies have been carried out by different workers on nutrition of stock plant and its effect on rooting of cuttings. However, using flowering stock grown under different integrated nutrient management schedule as mother plants still need to be evaluated. Keeping the above facts in mind, the present investigation was carried out to provide a more detailed insight into the role of integrated nutrient management of the production plant on rooting and production of quality cuttings from those plants.

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MATERIALS AND METHODS

Chrysanthemum cv. Purnima and Ajay were planted in open field condition at a density of 9 plants/m^2 during June, 2009 and June, 2010. Plants were pinched back to four leaves after one week and managed as production plants over a 5 months period. After the flowers have reached harvesting stage, the plants were headed back leaving 5-6 leaves on the stem. Thereafter, the lateral shoots that arise from the plants were excised and cut to a length of 8 cm under water to avoid a reduction in the water potential of the cuttings. Cuttings were harvested every week, leaving first two leaves of the axillary shoot on the mother plants.

One week prior to planting of the production plants, vermicompost (1 kg/m^2), full doses of phosphorous and potassium and half dose of nitrogen were incorporated into the beds according to the treatment requirements. The remaining half dose of nitrogen was applied after 30 days of planting. Nitrogen, phosphorous and potassium were applied through urea (46% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O), respectively. Vermicompost used in the experiment contained 2.12% N, 0.93% P_2O_5 and 1.11% K_2O. Biofertilizers, viz. *Azotobacter chroococcum*, phosphorous solubilizing micro-organisms (*Bacillus polymyxa* + *Pseudomonas striata*) and vesicular arbuscular mycorrhiza (*Glomus mosseae* + *G. fasiculatum*) were procured from the Division of Microbiology, Indian Agricultural Research Institute, New Delhi. *Azotobacter* and phosphorous solubilizing micro-organism were applied by dipping the roots of the cuttings into a slurry of 200 g of the inocula dissolved in one litre of 10 % sugar solution at the time of planting, whereas VAM (2 g/plant) was incorporated in the planting pit.

A randomized block design in factorial concept was used to evaluate the effect of 17 nutritional treatments as pre-harvest factors on two chrysanthemum cultivars Purnima and Ajay. Twelve plants were planted per replication per treatment (102 plots). The nutritional treatments comprised T_1 (Control, no fertilizer application), T_2 (30 g/m^2 each of NPK, Ad-hoc recommendation), T_3 (45 g/m^2 each of NPK), T_4 (22.5 g/m^2 each of NPK), T_5 (15 g/m^2 each of NPK), T_6 (30 g/m^2 each of NPK + Vermicompost), T_7 (30 g/m^2 each of NPK + Biofertilizers), T_8 (30 g/m^2 each of NPK + Vermicompost + Biofertilizers), T_9 (22.5 g/m^2 each of NPK + Vermicompost), T_{10} (22.5 g/m^2 each of NPK + Biofertilizers), T_{11} (22.5 g/m^2 each of NPK + Vermicompost + Biofertilizers), T_{12} (15 g/m^2 each of NPK + Vermicompost), T_{13} (15 g/m^2 each of NPK + Biofertilizers), T_{14} (15 g/m^2 each of NPK + Vermicompost + Biofertilizers), T_{15} (Vermicompost), T_{16} (Biofertilizers) and T_{17} (Vermicompost + Biofertilizers). Cuttings were harvested during the month of May from all the individual plots and rooted immediately following the procedure described below.

Adventitious rooting of 50 cuttings per treatment per replicate were studied in a portable poly tunnel lined hessian cloth using sterilized moist sand as rooting medium. Shoot tip cutting of 8-10 cm length were used in the experiment. Adequate water conditions of the cuttings were provided by intermittent misting. The maximum and minimum air temperature for the entire experiment was 35.5°C and 20.3°C respectively. After 25 days, the number of roots per cutting and mean root length were determined. Days taken for root initiation was recorded by taking out 3 cuttings randomly from each treatment daily after 15 days of sticking the cuttings. The day on which cutting showed root initiation was recorded. Per cent rooting success was determined as the total number of cuttings successfully rooted out of the total number of cuttings planted.

At harvest, 10 cuttings per treatment per replicate were sampled for the determination of total nitrogen concentration in the dry matter of cuttings. Samples were dried as described by Druege *et al.* (1998). The dry matter was analysed for total Nitrogen by Micro Kjeldahl method (Jackson 1973). Percentage of dry matter of sample were determined gravimetrically after drying for 24 hour.

The experimental data relating to each parameter were statistically analyzed by applying the technique of analysis of variance using factorial Randomized Block Design (Gomez and Gomez 1985). The level of significance for t-test was kept at 5% (P=0.05). Data were analyzed within the ANOVA of the SPSS software program, version 6.0.

RESULTS AND DISCUSSION

Nitrogen status of cuttings and number of cuttings harvested

Application of different inorganic and organic nutrients during the production phase had an appreciable influence on nitrogen status of cuttings at harvest and after rooting. The findings revealed maximum total nitrogen content at harvest (5.10 %) and after rooting (4.65 %) with the application of 15 g/m^2 each of NPK + Vermicompost (1 kg/m^2) + Biofertilizers during the production phase of the plant (Table 1). The addition of vermicompost and biofertilizers might have improved the soil physical conditions and nutrient status due to acceleration of microbial N-fixation in the rhizosphere of the mother plants. This leads to increased nutrient absorption and improved leaf nutrient contents, thus increasing nitrogen status of the cuttings taken from those plants. The enhancement of mineral uptake due to increase in specific ion fluxes at the root surface in the presence of plant growth promoting rhizobacteria has also been reported by Bertrand *et al.* (2000) and Bashan and Levanony (1991). There is a decrease in nitrogen concentration after rooting as nitrogen in the cuttings were used up for the rooting process and no further application of nutrient is being done after sticking the cuttings.

In general, cuttings of cultivar Purnima contain more total nitrogen at harvest (4.47 %) and after rooting (4.16 %) than those of cultivar Ajay (Table 1). This may be due to the different nutrient uptake capacity of the mother plants of the two cultivars. Irrespective of the cultivar, decreasing inorganic nitrogen concentrations and addition of

Table 1 Nitrogen status of the cuttings at harvest, after rooting and number of cuttings harvested per plant as influenced by integrated nutrient management during production phase of the plant (data are the pooled mean of two years)

Treatment		Total nitrogen content (% Dry matter)						No. of cuttings/plant		
		At harvest			After rooting			Purnima	Ajay	Mean
		Purnima	Ajay	Mean	Purnima	Ajay	Mean			
T_1	Control	3.51	3.65	3.58	3.21	3.05	3.13	29.90	23.16	26.53
T_2	NPK_{30} (Ad-hoc recommendation)	4.31	4.45	4.38	4.01	3.85	3.93	43.16	25.13	34.15
T_3	NPK_{45}	4.32	4.49	4.41	4.01	3.89	3.95	43.83	24.53	34.18
T_4	$NPK_{22.5}$	4.28	4.07	4.18	3.98	3.47	3.73	40.26	26.00	33.13
T_5	NPK_{15}	3.99	4.01	4.00	3.69	3.41	3.55	37.06	25.50	31.28
T_6	NPK_{30} + VC (1 kg/m^2)	4.43	4.54	4.49	4.13	3.94	4.04	43.26	26.23	34.75
T_7	NPK_{30}+BF	4.99	4.68	4.84	4.69	4.08	4.39	44.83	26.13	35.48
T_8	NPK_{30}+ VC (1 kg/m^2) + BF	5.08	4.72	4.90	4.78	4.12	4.45	46.70	24.36	35.52
T_9	$NPK_{22.5}$+ VC (1 kg/m^2)	4.44	4.49	4.47	4.14	3.89	4.02	40.16	24.86	32.51
T_{10}	$NPK_{22.5}$+Biofertilizers	4.93	4.61	4.77	4.63	4.01	4.32	36.13	25.56	30.85
T_{11}	$NPK_{22.5}$+ VC (1 kg/m^2) + BF	5.05	4.74	4.90	4.75	4.14	4.45	46.70	26.56	36.45
T_{12}	$NPK_{22.5}$+ VC (1 kg/m^2)	4.48	4.42	4.45	4.15	3.85	4.00	34.23	23.93	29.08
T_{13}	NPK_{15}+Biofertilizers	4.90	4.51	4.71	4.59	3.91	4.25	35.30	23.96	29.63
T_{14}	NPK_{15}+ VC (1 kg/m^2) + BF	5.28	4.91	5.10	4.98	4.31	4.65	36.73	26.30	31.51
T_{15}	VC (1 kg/m^2)	3.86	3.83	3.85	3.56	3.23	3.40	25.93	22.66	24.30
T_{16}	BF	4.02	3.95	3.99	3.72	3.35	3.54	30.26	22.20	26.23
T_{17}	VC + BF	4.06	4.11	4.09	3.76	3.51	3.64	29.26	23.40	26.33
Mean		4.47	4.36		4.16	3.76		37.86	24.73	
CD (P=0.05)										
Treatments (T)			0.06			0.06			1.08	
Cultivars (C)			0.02			0.02			0.37	
T × C			0.09			0.09			1.52	

N-Nitrogen, P-Phosphorous, K-Potassium, VC-Vermicompost, BF-Biofertilizers (*Azotobacter chroococcum* + solubilizing bacteria +VAM)

vermicompost and biofertilizers during the production phase resulted in significantly higher nitrogen content of the cuttings.

When fertilized with 22.5 g/m^2 each of NPK + Vermicompost (1 kg/m^2) + Biofertilizers, the plants produced a greater number of cuttings (36.45) (Table 1). Interaction effect also reveals maximum yield of cuttings in both cultivars Purnima and Ajay (46.70 and 26.56 respectively) with the same treatment. More number of cuttings/plant was harvested from cultivar Purnima (37.86) as compared to Ajay (24.70). The greater number of cuttings harvested with the application of inorganic fertilizers in combination with organic fertilizers may be due to better growth of the mother plants which may be ascribed to more availability of nutrients and more nutrient uptake. Similar findings were also reported by Wenzhong (2010), Khosa *et al.* (2011), Santos *et al.* (2011) and Twardowski *et al.* (2012) in herbaceous perennials.

Rooting of cuttings

Nutrition of the mother plants affected the rooting capacity and performance. Cuttings taken from plants grown under 22.5 g/m^2 each of NPK + Vermicompost (1 kg/m^2) + Biofertilizers nutritional treatment produced better rooting capacity as compared to other treatments which is indicated by minimum number of days taken for rooting (25.20), maximum root number (28.95) and root length (8.58 cm) (Table 2) regardless of cultivar used. The higher root number produced with lower dose of chemical fertilizer in combination with vermicompost and biofertilizers may be due to higher level of nitrogen concentration in cuttings excised from these mother plants, while increased root length can be the consequence of both accelerated root initiation and development. Hartmann *et al*. (2002) stated that nitrogen is important for nucleic acid and protein synthesis in plant tissue and hence resulted in better rooting performance of cuttings. Druege *et al*. (1998) reported that adventitious root formation of chrysanthemum cuttings was principally promoted by an increasing nitrogen supply and a corresponding increase in internal nitrogen concentrations. Roeber and Renther (1982) were of the opinion that supply of nitrogen in excess to the stock plants resulted in fewer harvested cuttings. Contrary to the observations recorded, Dreuge *et al.* (2000) observed a negative correlation between increasing N concentration and root initiation and development. Mc Avoy (1995) was also of the opinion that high nitrogen concentrations inhibit rooting. High nitrogen supply to the stock plants meeting or even surpassing the level necessary for maximum growth has often been observed to decrease subsequent rooting

Table 2 Rooting characteristics of chrysanthemum cuttings as influenced by integrated nutrient management during production phase of the plant (data are the pooled mean of two years)

Treatment		Days taken for rooting At harvest			No. of roots/plant After rooting			Length of longest root (cm)		
		Purnima	Ajay	Mean	Purnima	Ajay	Mean	Purnima	Ajay	Mean
T_1	Control	22.83	34.70	28.76	11.83	15.90	13.86	3.60	4.03	3.81
T_2	NPK_{30} (Ad-hoc recommendation)	21.70	31.63	26.66	25.66	25.96	25.81	7.20	8.13	7.66
T_3	NPK_{45}	20.86	31.96	26.41	26.53	22.36	24.45	5.63	6.93	6.28
T_4	$NPK_{22.5}$	22.93	33.96	28.45	24.30	21.36	22.83	5.83	5.13	6.48
T_5	NPK_{15}	22.43	35.96	29.20	20.76	20.36	20.56	5.70	5.23	5.46
T_6	NPK_{30}+ VC (1kg/m^2)	21.66	32.66	27.16	26.23	20.86	23.55	6.13	5.43	5.78
T_7	NPK_{30}+BF	20.80	32.86	26.83	26.03	21.16	24.50	6.73	5.66	6.20
T_8	NPK_{30}+ VC (1 kg/m^2) + BF	20.61	32.06	26.33	27.06	22.20	25.23	7.10	5.90	6.50
T_9	$NPK_{22.5}$+ VC (1 kg/m^2)	20.86	31.93	26.40	25.83	24.00	24.91	5.23	7.90	6.62
T_{10}	$NPK_{22.5}$+Biofertilizers	20.06	32.86	25.96	23.93	28.13	26.03	6.36	8.09	7.63
T_{11}	$NPK_{22.5}$+ VC (1 kg/m^2) + BF	19.73	30.66	25.20	29.40	28.50	28.95	8.26	8.90	8.58
T_{12}	$NPK_{22.5}$+ VC (1 kg/m^2)	20.96	32.90	25.66	18.23	21.86	20.05	5.13	6.73	5.93
T_{13}	NPK_{15}+Biofertilizers	19.66	31.66	25.68	21.16	22.20	21.68	5.23	6.90	6.06
T_{14}	NPK_{15}+ VC (1 kg/m^2) + BF	19.80	31.56	25.68	16.20	28.10	22.15	4.96	8.06	6.78
T_{15}	VC (1 kg/m^2)	21.30	33.70	27.50	13.16	21.10	17.13	4.13	4.26	4.21
T_{16}	BF	20.83	32.76	27.30	13.60	17.90	15.75	4.13	4.98	4.53
T_{17}	VC + BF	19.87	33.10	26.83	15.90	19.93	17.91	4.53	4.99	4.65
Mean		20.97	32.82		21.69	22.46		5.63	6.38	
CD (P=0.05)										
Treatments (T)			0.87			1.53			0.88	
Cultivars (C)			0.30			0.52			0.30	
T × C			1.23			1.16			1.01	

N-Nitrogen, P-Phosphorous, K-Potassium, VC-Vermicompost, BF-Biofertilizers (*Azotobacter chroococcum* + solubilizing bacteria +VAM)

of cuttings (Henry *et al*. 1992). Henry *et al.* (1992) reported that N fertilization of stock plants affected adventitious rooting, but there were no significant correlations between foliar N levels and measures of rooting response. Rowe *et al.* (2002 a) noted that tissue N concentration of stock plants increased with increasing application of N. However, the higher tissue N concentration did not translate to higher rooting percentage and survival (Rowe *et al.* 2002b).

Among the cultivars, Purnima took lesser time for rooting (20.97 days). However, number of roots/plant (22.46) and root length (6.38 cm) was more in cuttings of Ajay than Purnima (Table 2). Such differences between the two cultivars may be attributed to their different genetic makeup resulting in different growth rate. The percentage of healthy rooted cuttings was significantly higher in cultivar Ajay (96.30 %) as compared to Purnima (90.55 %) (Fig 1). In interaction, the percentage of healthy rooted cuttings of the two cultivars increased slightly with the addition of vermicompost and biofertilizers in the nutrition of the mother plants but not statistically significant.

Fresh weight of cuttings

Fresh weight of cuttings were significantly different for the different nutritional treatments, however the two cultivars obtained similar fresh weight of the cuttings irrespective of the treatments used. Application of 22.5 g/m^2 each of NPK + Vermicompost (1 kg/m^2) + Biofertilizers during the production phase resulted in higher fresh weight of cuttings at harvest (3.79 g) and after rooting (3.89 g). Average fresh weight of cultivar Purnima was higher than those of Ajay but not statistically significant (Table 3).

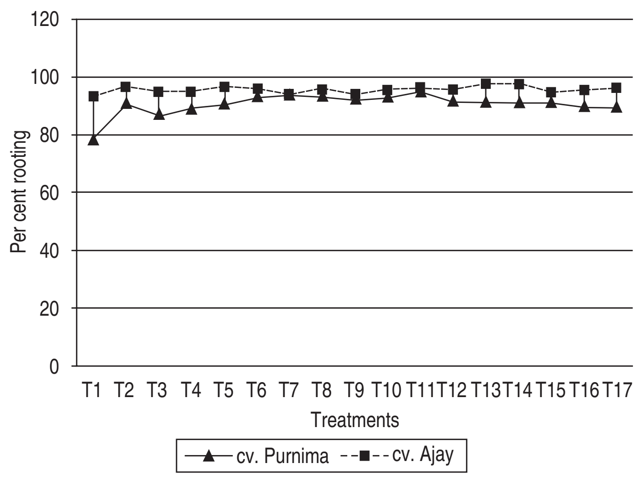

Fig 1 Per cent rooting in chrysanthemum cuttings as influenced by integrated nutrient management during production phase of the plant (data are the pooled mean of two years).

Table 3 Change in fresh weight of chrysanthemum cuttings before and after rooting as influenced by integrated nutrient management during production phase of the plant (data are the pooled mean of two years)

Treatment		Fresh weight of cutting (g)						Percent increase in fresh weight (%)		
		At harvest			After rooting			Purnima	Ajay	Mean
		Purnima	Ajay	Mean	Purnima	Ajay	Mean			
T_1	Control	1.70	1.78	1.74	2.10	1.97	2.04	23.53 (4.85)	10.67 (3.27)	17.10 (4.06)
T_2	NPK_{30} (Ad-hoc recommendation)	2.24	2.13	2.19	2.62	2.33	2.48	16.96 (4.12)	9.39 (3.06)	13.18 (3.59)
T_3	NPK_{45}	2.32	2.24	2.28	2.74	2.43	2.59	18.10 (4.25)	8.48 (2.91)	13.29 (3.58)
T_4	$NPK_{22.5}$	2.12	2.00	2.06	2.33	2.23	2.28	9.91 (3.15)	11.50 (3.39)	10.70 (3.27)
T_5	NPK_{15}	2.10	1.98	2.04	2.36	2.11	2.24	12.38 (3.52)	6.57 (2.56)	9.47 (3.04)
T_6	NPK_{30} + VC (1 kg/m^2)	2.52	2.43	2.48	2.73	2.63	2.68	8.33 (2.89)	8.23 (2.87)	8.28 (2.88)
T_7	NPK_{30}+BF	2.69	2.57	2.63	2.80	2.70	2.75	4.09 (2.02)	5.06 (2.25)	4.57 (2.14)
T_8	NPK_{30}+ VC (1 kg/m^2) + BF	3.73	3.54	3.64	3.83	3.71	3.77	2.68 (1.64)	4.80 (2.19)	3.74 (1.92)
T_9	$NPK_{22.5}$+ VC (1 kg/m^2)	2.48	2.29	2.39	2.65	2.56	2.61	6.85 (2.62)	11.79 (3.43)	9.32 (3.03)
T_{10}	$NPK_{22.5}$+Biofertilizers	3.49	3.34	3.42	3.56	3.47	3.52	2.01 (1.42)	3.89 (1.97)	2.95 (1.70)
T_{11}	$NPK_{22.5}$+ VC (1 kg/m^2) + BF	3.88	3.69	3.79	3.93	3.84	3.89	1.29 (1.13)	4.07 (2.02)	2.68 (1.58)
T_{12}	$NPK_{22.5}$+ VC (1 kg/m^2)	2.34	2.14	2.24	2.38	2.31	2.35	1.71 (1.31)	7.94 (2.82)	4.83 (2.07)
T_{13}	NPK_{15}+Biofertilizers	3.17	3.04	3.11	3.40	3.15	3.28	7.26 (2.69)	3.62 (1.90)	5.44 (2.30)
T_{14}	NPK_{15}+ VC (1 kg/m^2) + BF	3.17	3.09	3.13	3.26	3.21	3.24	2.84 (1.68)	3.88 (1.97)	3.36 (1.83)
T_{15}	VC (1 kg/m^2)	1.67	1.79	1.73	2.00	1.84	1.92	19.76 (4.44)	2.79 (1.67)	11.28 (3.06)
T_{16}	BF	2.10	1.94	2.02	2.21	2.14	2.18	5.24 (2.29)	10.31 (3.21)	7.77 (2.75)
T_{17}	VC + BF	2.49	2.26	2.38	2.58	2.35	2.47	3.61 (1.90)	3.98 (1.99)	3.80 (1.95)
Mean		2.60	2.49		2.79	2.65		8.62 (2.70)	6.88 (2.56)	
CD (P=0.05)										
Treatments (T)			1.03			0.81			0.09	
Cultivars (C)			NS			NS			NS	
T × C			1.45			1.15			0.28	

N-Nitrogen, P-Phosphorous, K-Potassium, VC-Vermicompost, BF-Biofertilizers (*Azotobacter chroococcum* + solubilizing bacteria +VAM), * Figures in parenthesis are square root transformed values.

Kadner and Zerche (1997) reported that fresh weight of cuttings increased with increasing N supply to the mother plants. Rober (1976) is of the opinion that increasing percentage of nitrate-nitrogen reduces the weight of cuttings as well as the weight of a single cutting. Although maximum fresh weight of cuttings at harvest and rooting was obtained with the application reduced inorganic fertilizers along with biofertilizers and vermicompost, the maximum percent increase in fresh weight (13.29 %) during the rooting process was observed with 45 g/m^2 each of NPK which is more than the recommended dose. This indicates that application of higher amount of inorganic fertilizers results in faster growth rate of the cutting which may be due the higher amount of foliar nitrogen content of stock plant.

In the present study the effect of INM during production phase has led to a significant difference in quantity and quality of cutting produced. Application of reduced amount of inorganic fertilizers in combination with biofertilizers and vermicompost produced healthier cutting and shown better rooting capacity as compared to higher doses of inorganic fertilizers alone. Based on these results, it has been found that cuttings can be taken from production plants when they were supplied with proper nutrition during their production phase.

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