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EFFECT OF SUBABUL (*Leucaena leucocephala*), UREA AND BIOFERTILIZER APPLICATION ON GROWTH, YIELD AND QUALITY OF STRAWBERRY cv. CHANDLER

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ABSTRACT

A field experiment was conducted at Research orchard, Division of Fruit Science, FOA, SKUAST-J, Udheywalla, Jammu in a randomized block design to study the effect of green leafy manure of subabul (*Leucaena leucocephala*) integrated with urea and biofertilizer (*Azotobacter* sp.) on growth, yield and fruit quality of strawberry cv. 'Chandler' during 2006 and 2007. The application of 25% nitrogen (N) through subabul + 75% N in the form of urea augmented with biofertilizer resulted in maximum plant height (20.9 cm), plant spread (27.8 cm), leaf area (70.0 cm^2), fruit size (38.4 x 28.9 mm), TSS (6.83° Brix), total sugars (4.85%), fruit weight (16.9 g), achene number $fruit^{-1}$ (365.8) and yield (385.2 q ha^{-1}). The results were, however, at par with the treatment where 50% N was applied through subabul + 50% N as urea augmented with biofertilizer. The present study revealed that in order to achieve comparable growth, yield and improved fruit quality as obtained with the use of recommended N doze through urea, the 50% N requirement could be replaced through subabul augmented with biofertilizer (*Azotobacter*).

Keywords: Anthocyanin, *Azotobacter*, biofertilizer, strawberry, subabul, urea, yield

INTRODUCTION

The strawberry (*Fragaria* x *ananassa* Duch.), an aggregate fruit, has attained the status of being one of the most important commercial soft fruit crop of the world after grapes (Umar *et al*., 2008). Strawberry fruits are in great demand as fresh fruit as well as in the processing industries for the use in preserves and confectionaries. Its popularity can be judged from the very fact that the production and area of strawberry world-wide has increased considerably over the past 15 years (Mudasar, 2007). In recent years more attention is paid to organic fruit production which involves minimum chemical use either as fertilizers or pesticides and emphasizes on the use of organic inputs in sustaining higher yields while reducing the harmful effects of chemicals on environment. Thus, the adoption of integrated nutrient management system (INM) is expected to enhance the soil productivity through a balanced use of mineral fertilizers in conjunction with organic sources of plant nutrients, including biological nitrogen fixation. The INM is ecologically safe, socially acceptable and economically viable system as it not only increases the soil and fruit productivity but also makes it a critical component for sustaining horticulture over long term (Umar *et al*., 2010). Therefore, an experiment was planned to study the effect of biofertilizer (*Azotobacter* sp.) and organics (subabul) at reduced levels of urea on growth, yield attributes and fruit quality in strawberry.

MATERIALS AND METHODS

A field trial was conducted at Research Orchard, Division of Fruit Science, FOA, SKUAST-J, Udheywalla, Jammu during 2005-06 and 2006-07. The experiment was laid in a randomized block design with twelve treatments and each treatment replicated three times. The treatments comprized of 100% recommended nitrogen doze (N) through subabul (T_1), 75% N through subabul + 25% N through urea (T_2), 50% N each through subabul and urea (T_3), 25% N through subabul + 75% N through urea (T_4), 100% N through urea (T_5), *Azotobacter* biofertilizer (T_6), *Azotobacter* + 100% N through subabul (T_7), *Azotobacter* + 75% N through subabul + 25% N through urea (T_8), *Azotobacter* + 50% N each through subabul and urea (T_9), *Azotobacter* + 25% N through subabul + 75% N through urea (T_{10}), *Azotobacter* + 100% N through urea (T_{11}), and untreated control (T_{12}). Twenty runners of strawberry cv. 'Chandler' were established in each experimental unit of 1.5 x 1.5 m size with plant spacing of 25 × 40 cm under plastic mulch in the first week of November. The strawberry runners were dipped in 10% sugar slurry of biofertilizer (*Azotobacter* sp.) culture before planting. Soil was also inoculated with *Azotobacter* culture after two months @ 2 kg ha^{-1}. The subabul and urea was applied on nitrogen equivalent basis of 150N: 80P: 45K kg ha^{-1}. The required quantity of subabul was applied as green manure 20 days before transplanting of strawberry runners in the respective plots to allow proper decomposition. The urea was applied in two split doses, viz., first half dose of urea was mixed into soil prior to planting and second half applied before flowering. Phosphorus (P_2O_5) and potassium (K_2O) was worked out after subtracting the quantity of each of these nutrients supplied by organic and the remaining quantity applied through single super phosphate (SSP) and muriata of potash before planting. All the experimental plots were given uniform cultural operations including recommended plant protection measures. The data on vegetative growth like plant height, spread and leaf area were recorded at peak fruiting time. Plant spread was measured with the help of a measuring scale from north to south and east to west directions. The average of both the directions was taken as plant spread. The leaf area of three representative leaves $plant^{-1}$ was measured with the help of a leaf area meter (Systronics 211 model). Total soluble solids (TSS), titratable acidity (as citric acid), total sugars and ascorbic acid contents were estimated as per AOAC methods (1995). Total anthocyanin was measured at 535 nm in UV-visible spectrophotometer according to the method of Ranganna (1995). The total number of berries per plant and average berry yield per plant were worked out at harvest and data expressed in terms of q ha^{-1}. Data was subjected to statistical analysis as prescribed by Panse and Sukhatme (2000).

RESULTS AND DISCUSSION

Effect on plant growth and yield parameters

All the treatments proved superior over control in improving the plant height (Table 1). A maximum height of 20.94 cm was recorded in plants receiving biofertilizer (*Azotobacter*) + subabul*:* urea (25:75). However, these were at par with the plants receiving *Azotobacter* + 100% N through urea as well as with the application of *Azotobacter* + subabul: urea (50:50), registering 20.51 and 20.22 cm of plant growth, respectively. The results revealed that subabul application generally increased plant spread and leaf area as compared to the plants receiving no subabul. However, maximum plant spread (27.81 cm) and leaf area (70.02 cm^2) was observed in plants receiving *Azotobacter* + subabul: urea (25:75) but were at par with the plants where application of 100% N was made in the form of urea + *Azotobacter* as well as with the application of *Azotobacter* + subabul: urea (50:50). Sufficient nitrogen supply must had been maintained through atmosphere nitrogen fixed by *Azotobacter*, whereas slow release of nitrogen by subabul and urea acting as a ready source of nitrogen might have resulted in increase in vegetative growth characters of strawberry in these treatments (Umar, 2007).

Fruit weight (16.39 g) was maximum in plants receiving *Azotobacter* + subabul : urea (25:75) closely followed by 16.53 and 16.36 g recorded in plants receiving 100% nitrogen as urea + *Azotobacter* as well as with the application of *Azotobacter* + subabul: urea (50:50). Ghosh (1990) observed increased fruit weight with increased application of nitrogen in sweet orange cv. 'Mosambi' which also supports the present findings. The increased berry weight in strawberry may be attributed to higher number of achenes under these treatments. Normal development of strawberry receptacle is dependent on the release of hormones from unfertilized ovule of achene as reported by Nitsch (1950); whereas Kaul (1996) has suggested that the potential weight of berry is a function of total number of achenes on the surface and amount of receptacle developed per achene.

Table 1: Effect of subabul (*L. leucocephala*), urea and biofertlizer (*Azotobacter*) on growth and yield parameters of strawberry crop cv. 'Chandler'

Treatments (equivalent to 150 kg N ha^{-1} added)	Plant growth			Yield parameters			
	Plant height (cm)	Plant spread (cm)	Leaf area (cm^2)	No. of berries plant^{-1}	Fruit weight (g)	No. of achenes fruit^{-1}	Yield (q ha^{-1})
Subabul (100%)	16.77	24.36	60.54	16.9	13.44	334.12	227.22
Subabul : urea (75:25)	18.13	25.52	63.65	18.6	13.11	338.80	243.74
Subabul : urea (50:50)	19.74	26.05	66.59	20.9	15.33	358.95	319.38
Subabul : urea (25:75)	19.98	26.87	67.50	21.3	16.22	361.70	344.51
Urea (100%)	19.87	26.68	66.80	21.3	15.89	359.49	336.79
Azotobacter	12.21	19.18	34.82	14.8	12.80	332.69	189.54
Azotobacter + subabul (100%)	17.71	25.33	63.43	18.4	13.61	343.64	250.07
Azotobacter + subabul : urea (75:25)	18.89	26.18	65.02	19.6	13.61	348.84	265.74
Azotobacter + subabul : urea (50:50)	20.22	27.40	68.37	22.4	16.36	362.47	366.55
Azotobacter + subabul : urea (25:75)	20.94	27.81	70.02	22.7	16.93	365.78	385.19
Azotobacter + urea (100%)	20.51	27.49	68.66	22.1	16.53	364.58	366.01
Control	10.98	16.02	30.45	12.4	12.38	295.93	153.20
S.Em. (±)	0.591	0.590	1.037	0.332	0.506	0.710	11.04
$CD_{0.05}$	1.19	1.19	2.09	0.67	1.02	1.43	22.26

The total number of berries plant^{-1} ranged between 12.4and 22.7 with maximum in plants which received *Azotobacter* + subabul: urea (25:75) and minimum in control (Table 1). However, the treatment *Azotobacter* + subabul: urea (25:75) was at par with the treatments where *Azotobacter* + subabul: urea (50:50) was applied as well as when 100% nitrogen was applied through urea augmented with *Azotobacter*. Similarly, maximum achene number (365.78) was recorded in fruits where plants received *Azotobacter* + subabul: urea (25:75). However the results were statistically at par with the plants receiving *Azotobacter* + urea (100%) registering 364.58 number of achenes fruit^{-1}. Although the treatment *Azotobacter* + subabul: urea (25:75) was superior in enhancing yield (385.19 q ha^{-1}) among different treatments tested, the yield did not significantly differ from the yield of 366.55 and 366.01 q ha^{-1} obtained from the plots receiving *Azotobacter* + subabul: urea (50:50) and *Azotobacter* + urea (100%), respectively. The improvement in yield in present study is supported by similar increase in case of okra observed by Tripathy *et al*. (2004) who reported that integrated use of inorganic, chemical fertilizers with organic or biological sources of nutrients resulted in gradual and steady nutrient release during growth period as well as enhanced the biological activity and nutrient supply to the crop. Similar arguments for higher yields in okra and chilli have been documented by other workers (Sharma and Bhalla, 1995; Hangarage *et al.*, 2001; Dar, 2006).

Effect on fruit quality

The fruit size was greatly improved by different treatments of subabul, urea and biofertilizer (*Azotobacter*) when applied alone or in combination (Table 2). Maximum fruit size (38.37 × 28.92 mm) was observed in fruits harvested from plants receiving *Azotobacter* + subabul: urea (25:75) or subabul: urea (50:50) + *Azotobacter* (37.61 x 28.16 mm). The present findings are in line with Dudi *et al*. (2004) who opined that nitrogen application improved the efficiency of metabolic process of plant and thus encouraged plant growth and consequently resulted in increase in fruit size.

Table 2: Effect of subabul (*L. leucocephala)*, urea and biofertilizer (*Azotobacter*) on fruit quality of strawberry crop cv. 'Chandler'

Treatments (equivalent to 150 kg N ha^{-1} added)	Fruit size		TSS (°Brix)	Titratable acidity (%)	Total sugars (%)	Ascorbic acid (mg 100 g^{-1} fresh berries)	Anthocyanin content (OD at 535 nm)
	Length (mm)	Diameter (mm)					
Subabul (100%)	33.03	24.29	6.76	0.74	4.81	68.59	0.174
Subabul : urea (75:25)	35.36	25.63	6.75	0.74	4.78	68.91	0.176
Subabul : urea (50:50)	36.68	27.70	6.75	0.75	4.78	71.51	0.185
Subabul : urea (25:75)	37.57	28.03	6.76	0.75	4.83	71.70	0.185
Urea (100%)	36.89	27.76	6.71	0.75	4.42	72.37	0.185
Azotobacter	32.05	23.97	6.47	0.74	4.11	67.37	0.165
Azotobacter + subabul (100%)	34.67	25.03	6.83	0.76	4.83	69.59	0.178
Azotobacter + subabul : urea (75:25)	35.38	25.35	6.82	0.75	4.82	69.72	0.181
Azotobacter + subabul : urea (50:50)	37.61	28.16	6.82	0.76	4.83	72.22	0.193
Azotobacter + subabul : urea (25:75)	38.37	28.92	6.83	0.76	4.85	72.86	0.193
Azotobacter + urea (100%)	38.13	28.50	6.65	0.77	4.50	73.94	0.194
Control	31.14	23.29	6.43	0.70	3.90	62.45	0.163
S.Em. (±)	0.546	0.432	2.074	-	0.011	0.963	0.001
$CD_{0.05}$	1.10	1.87	0.06	ns	0.023	1.94	0.002

The total soluble solids were highest (6.83° Brix) in fruits receiving 100% nitrogen in the form of subabul + *Azotobacter* as well as in the fruits where *Azotobacter* + subabul: urea (25:75) was applied. The acidity of strawberry increased with increase in concentration of urea as source of nitrogen. Highest titratable acidity (0.77%) was recorded in treatment *Azotobacter* + urea (100%) and lowest in control which is in line with the results of Umar *et al.* (2009). The total sugar content reached to a highest level of 4.85% in treatment *Azotobacter* + subabul: urea (25:75) and was closely followed by the value of 4.83% in treatments subabul: urea (25:75), *Azotobacter* + subabul (100%) and *Azotobacter* + subabul: urea (50:50). Long (1935) observed that during strawberry fruit ripening carbohydrate reserves of roots and stem are drawn upon heavily and hydrolyzed into sugars in fruits. Ascorbic acid and anthocyanin contents was highest (73.94 mg 100 g^{-1} fresh berries and 0.194 OD), respectively, when 100% nitrogen was applied as urea + *Azotobacter* and the results were at par with the treatments comprizing of *Azotobacter* + subabul: urea (50:50) and *Azotobacter* + subabul: urea (25:75). The increase in vitamin C and anthocyanin contents are in consonance with similar findings in strawberry by Kopanaski and Kawecki (1994) who reported that nitrogen application increased the vitamin C content. The involvement of nitrogen at metabolic level in regulating the physiological and biochemical processes, especially in phenylalanine ammonia lyase activity (PAL) seems to be the primary cause for increase in red pigment (peonidin-3-glucocide) responsible for red colouration in strawberry. These studies are in agreement with the findings of Rana and Chandel (2003), who reported improvement in fruit quality of strawberry cv. 'Chandler' by the application of nitrogen and biofertilizers.

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