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Carbon Sequestration under Saffron (*Crocus sativa*) Cultivation as Influenced by Different Levels of Organic Manure and Inorganic Nitrogen

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Abstract: The effect on carbon sequestration under saffron (*Crocus sativa*) cultivation as influenced by different levels of organic manure and inorganic nitrogen was investigated in a field experiment at Dryland (Karewa) Agriculture Research Station, Budgam, Kashmir. The farm yard manure was applied at 0, 30 and 60 t ha^{-1} and inorganic nitrogen at 0, 45 and 90 kg ha^{-1}, respectively along with *Azotobacter*. The organic carbon content was recorded at three stages, immediately after flowering (Oct-Nov), during vegetative growth stages in (Feb- March) and (April-May), respectively. The pooled data indicated that at stage I, there was a significant increase in the organic carbon in the soil with the application of maximum amount of FYM and nitrogen. The mean organic carbon content of the soil increased from 9.22 g kg^{-1} to 15.34 g kg^{-1} when FYM was applied in conjugation with inorganic nitrogen. However, the highest and significant organic carbon (17.50 g kg^{-1}) was observed in the treatment in which nitrogen was applied at 90 kg ha^{-1} and FYM at 60 t ha^{-1} an increase of 156.9 per cent over the control (6.81 g ha^{-1}). Similar trends were also observed at stage II and III, respectively. However, the effect of *Azotobacter* was found significant only at stage-III.

Key words: *Azotobacter, carbon sequestration, FYM interaction, nitrogen, saffron*

Introduction

Saffron (*Crocus sativus* L.) is the most expensive spice, and is regarded as one of the economy regulating factor in agriculture sector for the development of Jammu and Kashmir State. However, the crop has a very low harvest index (stigma/biomass) (Molafilabi 2004) and hence for increasing the yield of the crop is very important which can be realized by following improved cultural methods (Munshi 2002; Fernandez 2004). Saffron is a perennial crop with a life span of 4-5 years and it requires an adequate amount of nutrients. In traditional saffron culture, no fertilizers are applied to the crop, except initial application of 5-10 tonnes farm yard manure at planting, the field is left even for 10-15 years or even more, without any external chemical fertilizer.

In Kashmir, the crop is grown in Pampore belt under rainfed conditions with blanket/ no fertilizer application. The subsistence agriculture without fertilizer or organic matter addition depleted the

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nutrients and organic carbon in these soils. Due to the deterioration of soil health, the quantity and quality of saffron yield have remarkably declined during the last decade (Nehvi *et al.* 2004 and Behdani 2005). Organic manures improve physical, chemical and biological properties of soils besides carbon sequestration (Sofi *et al.* 2009) that improves crop yields. The bio-fertilizers, which are low cost and eco-friendly, have tremendous potential for supplying the nutrients which can reduce the chemical fertilizer dose by 25-50 % (Vance 1997).

For **carbon** credits to be meaningful, sustained **carbon** sequestration for decades or longer periods is required. It has been shown that improved land management could result in sequestration of a substantial amount of **carbon** in the soils within decades, and therefore, can be an important option in reducing atmospheric CO_2 concentration (Upadhyay *et al.* 2005). Keeping this in view and the absence of any standardized nutritional protocol for saffron in the Kashmir, India, the present study was conducted under the project "Standardization of Integrated Nutrient Management for Saffron" in Dryland (Karewa) Agriculture Research Station, Budgam, with an active support and assistance of ICAR under its flagship programme-"Horticulture Mini-Mission-HTMM-2.22".

Materials and Methods

A field experiment was conducted at Dryland (Karewa) Agriculture Research Station, Budgam for 4 years (2007-2010) to study the effect of different fertility management practices on saffron and the results were further tested in farm trials under one of the flagship programmes of NAIP during 2009-2014. The landform of the farm was broad valley with arable land use, having mid to high altitude, temperate agro-climatic zone, moist sub-humid, agro-ecological zone with growing period of 150-210 days (Rana *et al.* 2000; Kirmani *et al.* 2013). The annual precipitation varies from 600- 900 mm. The maximum precipitation is received in the form of snow during winter. Sub-zero temperatures are recorded from November to January. The mean maximum temperatures reach to 24.5^{o}C in the month of July and mean minimum temperature reaches minus 2.0^{o}C in the month of January. Moisture regime is udic with mesic temperature regime (Kirmani 2005).

The experiment was conducted in a randomized block design with three replications. Farmyard manure was applied at 0, 30 and 60 t ha^{-1} and inorganic nitrogen at 0, 45 and 90 kg ha^{-1}, respectively along with *Azotobacter*. The organic carbon content was recorded at three stages, immediately after flowering (Oct.-Nov.), during vegetative growth stages (Feb.- March) and (April- May), respectively. Soil texture was clay loam with a high plasticity. The soil samples collected from each treatment were analysed for various physical and chemical properties like soil reaction and electrical conductivity in 1:2.5, soil: water suspension (Jackson 1973). Organic carbon was determined by the wet digestion method of Walkley and Black (1934) as modified by Walkley (1935). The initial status of N, P and K of soil was 210.28 kg ha^{-1}, 19.57 kg ha^{-1} and 298.12 kg ha^{-1}, respectively. The data was statistically analysed using statistical software 'MINITAB'.

Results and Discussion

The pH of the experiment site ranged from 6.7 to 7.65 and EC was low with a mean value of 0.11 dSm^{-1}. Based on the means of the pooled data, the results indicated that at stage I, there was a significant increase in the organic matter content in the soil with the increase in the application of FYM from 0 to 60 t ha^{-1} and N from 0 to 90 kg ha^{-1} (Fig. 1). There was an increase in the mean organic carbon content of the soil from 9.22 g kg^{-1} to 15.34 g kg^{-1} when FYM was applied in conjugation with inorganic nitrogen.

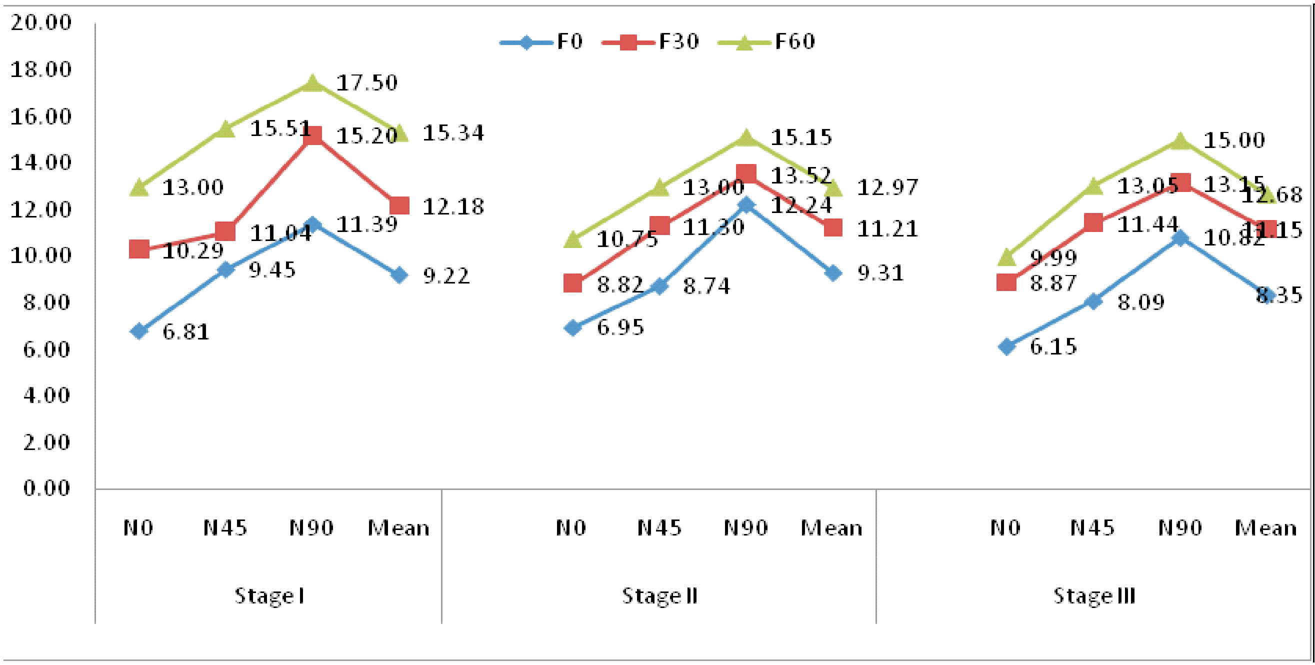

Fig. . Organic Carbon (g kg^{-1}soil) content as influenced by FYM and Nitrogen at different growth stages. CD (P=0.05) for N and F =0.2, 0.12 and 0.15 for three stages, N x F = 0.32, 0.21 and 0.26 for stage I, stage II and stage III respectively.

However, the highest and significant organic carbon (17.50 g kg^{-1}) was observed in the treatment in which FYM was applied @60 t $ha^{-1}$and nitrogen @90 kg ha^{-1}, an increase of 156.97 per cent over the control (6.81 g ha^{-1}). Such increase was also noticed at stage II and Stage III, wherein the mean organic carbon content increased from 9.31 g $kg^{-1}$to 12.97 g $kg^{-1}$and 8.35 g kg^{-1} to 12.68 g kg^{-1}, respectively. Their interaction effect has shown a significant increase of 117.98 and 143.90 per cent which corresponds to 15.15 g $kg^{-1}$and 15.00 g $kg^{-1}$from their respective control of 6.95 g $kg^{-1}$and 6.15 g kg^{-1} at both the stages. The increase in the organic carbon content in soil with the increase in FYM has already been documented (Fang *et al.* 2005; Majmudar *et al.* 2008; Kirmani *et al.* 2010; Sofi *et al.* 2013). There has been a slight decrease in OC from stage I to stage III might be due to the seasonal change in crop from Oct.-Nov. in stage I and April-May in stage III due to less decomposition rates owing to low in the valley (Sofi *et al. 2009;* Javaria and Khan 2011).

The effect of *Azotobacter* on the organic carbon content was also observed in conjugation with the interaction of FYM and nitrogen. The results revealed that the mean effects of N, FYM and *Azotobacter* and their interaction were non-significant in stage I and stage II (Fig. 2 and 3) while the effect of *Azotobacter* was significant only at stage III (Fig. 4). Among the interaction effects, FYM and N were found to be significant at all the stages of growth. The highest organic carbon content of 13.93 g kg^{-1} was observed when FYM at 60 t ha^{-1} was applied with *Azotobacter* which showed an increase of 58.29 per cent over its control of 8.80 g kg^{-1}. Similarly, 11.42 g kg^{-1} of organic carbon was observed when higher levels of FYM was applied without *Azotobacter* which had 44.55 per cent increase over its respective control of 7.90 g kg^{-1}. There was significant increase in the overall effect of *Azotobacter* on organic carbon from 9.81 g kg^{-1} to 11.65 g kg^{-1} (18.75 per cent increase). The application of *Azotobacter* leads to increase in soil organic carbon and improves soil health (Schuman *et al.* 2002; Kirmani *et al.* 2014; Kashyap *et al.* 2017).

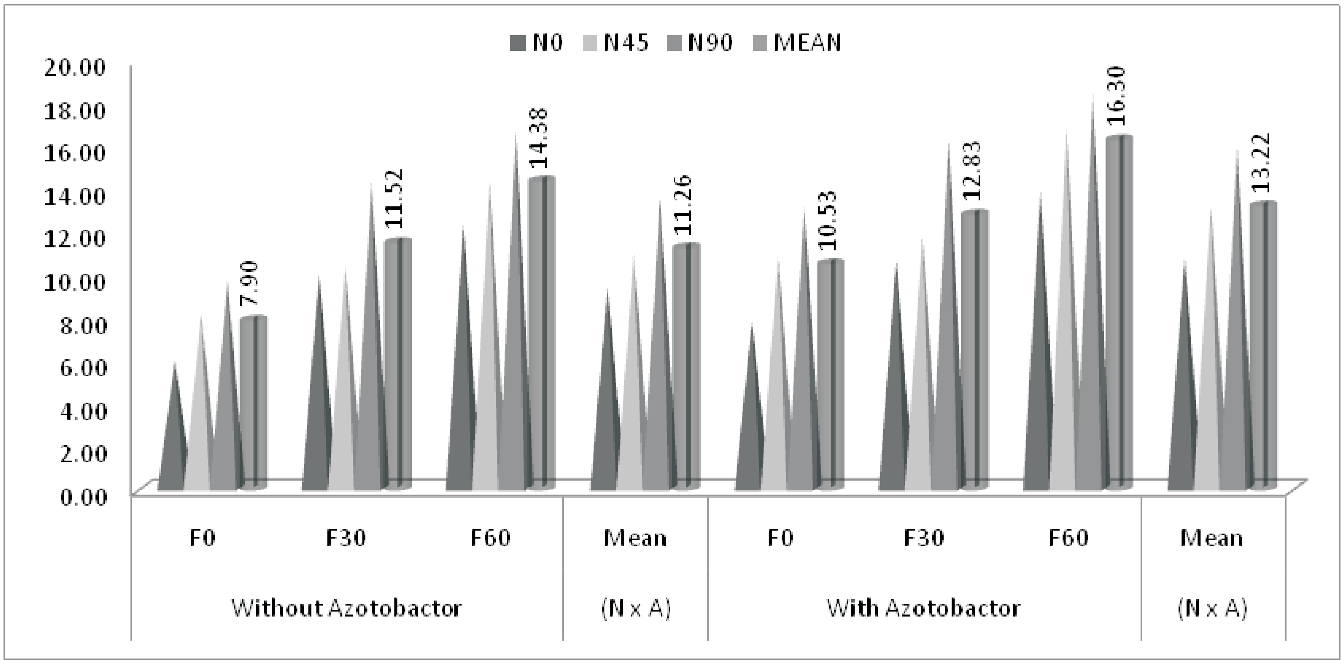

Fig. . Organic Carbon (g kg^{-1} soil) content at growth stages-I CD (P=0.05) for N and F = 0.2, N x F =0.32, effect of *Azotobacter* N x A, F x A and N x F x A were found non-significant.

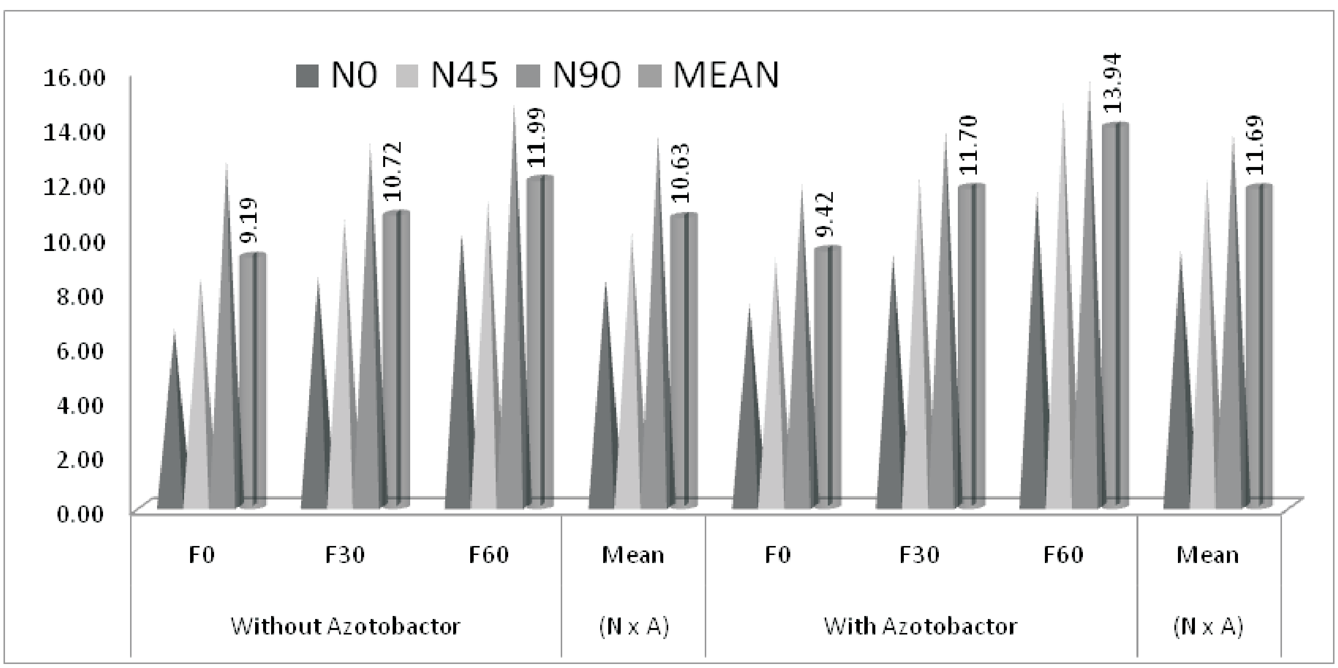

Fig. . Organic Carbon (g kg^{-1}soil) content at growth stages II. CD (P=0.05) for N and F = 0.15, A= 0.12, N x F =0.26, effect of N x A, F x A and N x F x A were found non-significant.

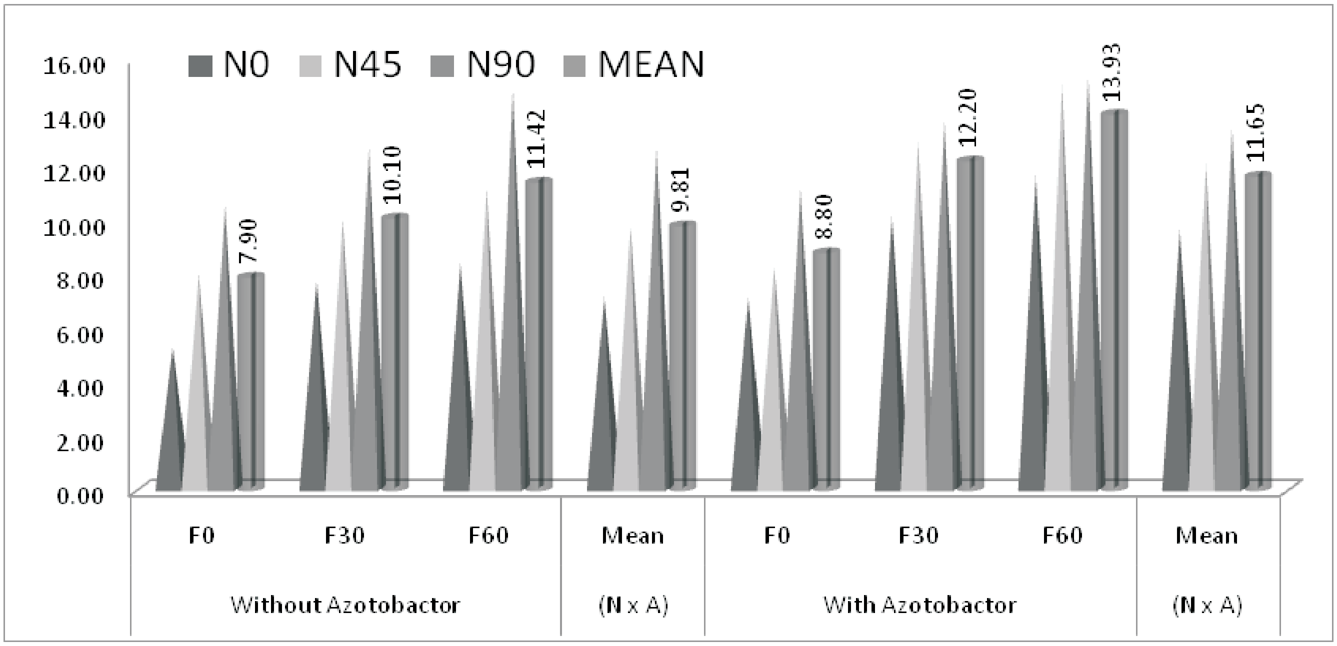

Fig. . Organic Carbon (g kg^{-1}soil) content at different growth stages-III effect of *Azotobacter* N x A, F x A and N x F x A were found significant.

The impact of *Azotobacter* was statistically significant on corm production but non-significant on saffron yield. There was positive influence of INM on physico-chemical properties of soil and available forms of NPK. The impact of integrated phosphorous and potassium management on saffron yield has also been recorded (Kirmani *et al*. 2013).

Conclusion

It can be inferred that different levels of organic manure and inorganic nitrogen have positive impact on carbon sequestration. There was a reduction in the rates of soil organic carbon depletion due to the application of FYM with inorganic nitrogen. It was also observed that any modification in land use or management practice can bring about the change in soil carbon stocks. *Azatobacter* was found to increase the organic C content in soil upto some extent. The minimal use of chemical fertilizers is found to affect the quantity and quality of the saffron yield in the long term.

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