Review Article

Integrated Nutrient Management in Sunflower (*Helianthus annuus L.*) – A Review

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Abstract

Sunflower is an important oilseed crop in world in terms of its quantity and quality. Excessive use of chemical fertilizers leads to deterioration of soil health as well as decline in productivity. So integrated nutrient management in sunflower (*Helianthus annuus* L.) is one of the strategies which exhibited significant effect on growth, yield, nutrient uptake, economics and soil health on a sustainable basis. Chemical fertilizers along with organics and secondary and micro nutrients resulted in increase seed and oil yield as well as net returns in case of sunflower.

Keywords: Sunflower, nutrient management, oilseed crop, micro nutrients

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Introduction

Sunflower (*Helianthus annuus*L.) is popularly known as 'Surajmukhi'. It is one of the most important high quality oilseed crop widely cultivated all over world and it ranks third in production next to soybean and groundnut. Fertilizers alone cannot sustain the productivity of soils on a sustainable basis rather lead to deterioration in health of our arable soils. Organic manures have been used since long to enhance the efficiency and reduce the requirement of chemical fertilizers. In recent years, integrated nutrient management has a very crucial role to sustain the soil productivity. The combined application of organic manures and inorganic fertilizers along with micronutrients will bring about enhanced productivity in oilseed crops.

Effect of integrated nutrient management on growth of sunflower

Byrareddy*et al.*[1]conducted a field experiment during *kharif,* 2006-07 at Dharwad and reported that the higher plant height (32.57, 142.33 and 150.97 cm in CMS-234A and 36.23, 145.67 and 152.60 cm in 6D-1 at 30, 60 and 90 DAS respectively) and higher number of leaves (19.10 and 17.47; 28.00 and 33.67 in CMS-234A and 6D-1 at 30 and 60 DAS respectively) were obtained with application of FYM 8 t/ha + RDF (62.5: 75: 62.5 kg/ha) over control. Ahmad and Jabeen [2] reported that significant increase in growth in terms of plant height, leaf area, stem diameter, fresh and dry biomass was recorded with combination of organic manure. Rani *et al.* [3] reported that application of sulphur at the rate of 60 kg/ha significantly increased the leaf area index, dry matter production and stem girth at 30, 60 DAS and harvest over 40, 20 kg S/ha and control. However, days to 50% flowering decreased with increasing levels of sulphur up to 60 kg/ha. Pavani*et al.*[4] observed that application of 30 kg S/ha depicted maximum plant height (178.5 cm), stem girth (10.67 cm) and dry matter accumulation (111.4 g/plant) over no sulphur application and application of 15 kgS/ha. Gajbhiye*et al.*[5]) at Latur concluded that higher plant height, number of leaves/plant, leaf area/plant, stem girth, dry matter production and head diameter was obtained with application of 150% RDF which was at par with application of 100% RDF (60 kg N + 30 kg P_2O_5 + 30 kg K_2O/ha) and RDF + FYM 5t/ha. Thakur *et al.*[6] conducted a field experiment on sandy loam soil during *kharif*2012 at Rajendranagar, Hyderabad and revealed that maximum plant height, LAI, dry matter accumulation and stem girth was found with application of RDF + 12.5 kg/ha humic acid granules over RDF (60:60:30 kg N, P_2O_5 and K_2O/ha) and RDF + FYM @ 5 t/ha.Rasool*et al.* [7] observed from an experiment concluded that application of FYM @ 20 t/ha + 120 kg N/ ha + 60 kg S/ha produced higher plant height, LAI and dry matter accumulation which was statistically superior overcontrol. Mollashahi*et al.*[8] studied the effect of different doses of nitrogen and potassium on yield and yield components of sunflower depicted that plant height (140.51 cm) obtained from consumption of 225 kg/ha nitrogen was significantly higher than control. At the same time, the highest plant height (142.91 cm) was found from consumption of 150 kg/ha potassium than control. Banerjee *et al.* [9] observed that maximum plant height (104.68 and 127.67 cm), leaf area index (1.73 and 1.51) and dry matter production (74.38 and 99.79 g/plant) at 50 and 100 DAS was obtained with application of 125% RDF ($N_{100}P_{50}K_{50}$) which was at par with 100% RDF ($N_{80}P_{40}K_{40}$) and significantly differed from farmers fertilizer practice ($N_{60}P_{30}K_{30}$). Pujar*et al.* [10] revealed that application of 30 kg S/ha + sulphur oxidizing

biofertilizer produced higher plant height (44.67, 142.04 and 195.00 cm), number of green leaves/plant (13.87, 18.26 and 10.56), leaf area (23.82, 42.13 and 26.68dm^2), LAI (1.31, 2.34 and 1.48) and dry matter accumulation (5.86, 38.15 and 59.64 g/plant) at 40,80 DAS and at harvest respectively which was on par with 30 kg S/ha alone and 20 kg S/ha + sulphur oxidizing biofertilizer) over other treatments. Tahir *et al.* [11] reported that application of boron @ 4 kg/ha resulted in tallest plants (189.14 cm) and thickest stem diameter (2.21 cm) with corresponding values of 182.24 cm and 1.83 cm, respectively under control. He also reported decrease in growth parameters with increase in Boron level. Biswas and Poddar [12] conducted an experiment during three consecutive *rabi*seasons during 2011-12 to 2013-14 at Nakasipara, Nadia, West Bengal and interpreted that maximum plant height and dry matter production were observed with application of N @ 125 kg/ha + S @ 50 kg/ha which was at par with N @ 100 kg/ha + S @ 40 kg/ha. Burirо*et al.* [13] from an experiment revealed that application of PM @ 6 t/ha +75% recommended dose of NPK gave rise to significantly higher plant height (201.0 cm), stem girth (3.71 cm) and number of leaves per plant (20.70) which was at par with PM @ 8 t/ha +50% recommended dose of NPK with corresponding values of 197.00 cm, 3.65 cm and 20.50 respectively. Debina*et al.* [14] observed that plant height (157.4 cm), leaf area (7695.5 cm^2/plant)andLAI(4.275cm^2/plant)at60DASwerefoundtobemaximumwithapplication of 100% RDF which was at par with 150% RDF having values 156.6 cm, 7500 cm^2/plant and 4.166 cm^2/plant while the lowest was observed in control having values 129.6 cm, 3821.8cm^2/plantand2.123cm^2/plantforplantheight,leafareaandLAIrespectively.Butthe highest total dry matter accumulation (214 g/plant) at 60 DAS and stem girth (2.03 cm) was obtained with application of 100% RDF + FYM + *Trichoderma viride*over control with corresponding values of 99 g/plant and 1.50 cmrespectively. Pattanayak*et al*. [15] carried out a field experiment at Odisha University of Agriculture and Technology and observed that the maximum stem girth was recorded with RDF + Boron @ 1 kg/ha at bottom, mid and upper positions, which was on par with RDF + $ZnS0_4$ @ 25 kg/ha at all the stages of observations viz., 30, 45, 60, 75 DAS and at harvest. Ravishankar*et al.*[16] stated that application of nitrogen @ 126kg/ha, phosphorus @ 90 kg/ha and potassium @ 60 kg/ha having N/P fertilizer ratio of 1.4 gave rise to higher plant height, stem girth, leaf area and total dry matter production which was on par with application of 117 kg N/ha and 90 kg P_2O_5/ha with N/P fertilizer ratio of 1.30and application of 108 kg N/ha and 90 kg P_2O_5/ha with N/P fertilizer ratio of 1.20.Choudhary*et al*. [17] from a field experiment at Allahabad concluded that application of 45 kg sulphur/ha + sulphur oxidizing biofertilizer produced significantly higher plant height (154.00 cm), leaf area (99.55 dm^2), leaf area index (7.29) and dry matter production (68.77g/plant) whereas lowest were found in control (0 kg S/ha). Kumar *et al.*[18] from an investigation concluded that RDF + compost @ 5.0 t/ha registered maximum dry matter accumulation in stem and capitulum at harvest (105.67 and 30.37 g/plant respectively) which was at par with RDF + compost @ 2.5 t/ha (85.08 and 28.44 g/plant. Adhikary *et al*. [19] conducted a field experiment in two consecutive *rabi* seasons of 2013 and 2014 at West Bengal, India and confirmed that application of 125% RDF ($N_{100}P_{50}K_{50}$) recorded significantly higher plant height (1.69 m), basal girth (9.08 cm) and capitulum diameter (17.15 cm) than any other treatments. Dambale *et al.*[20] conducted a field experiment at Latur and concluded that maximum plant height (193.67 cm), LAI at 75 DAS (3.47) and total dry matter accumulation/plant (132.67 g) were recorded with application of 100 % RDF + FYM @ 5 t/ha while the lowest was observed in soybean residue @ 5 t/ha. Mehmood *et al.*[21] carried out a field experiment during 2009 at Agronomic Research Area, University of Agriculture Faisalabad, Pakistan found that higher plant height (155 cm) and stem diameter (2.17 cm) was obtained with application of 150 kgN/ha whereas the lowest was obtained in control. Similarly, application of 2 kg B/ha produced higher plant height (148cm)and stem diameter(2.08cm)whereas control gave minimum values.

Effect of integrated nutrient management on yield attributing characters and yield ofsunflower

Byrareddy*et al* [1] revealed that application of FYM 8 t/ha + RDF (62.5: 75: 62.5 kg/ ha) registered substantially higher capitulum diameter (20.67 cm), seed yield per plant (18.52 g), seed filling percentage (76.33%) and processed seed yield (9.65 q/ha) closely followed by application of 50% N (VC) + 50% N (urea) + SSP whereas control treatment produced the lowest. From a field experiment, Shekhawat and Shivay [22] concluded that application of 50 kg S/ha reported significantly higher capitulum diameter (18 cm), number of seeds/ capitulum (902.2), seed weight per capitulum (37.2 g), 1000 seed weight (42.8 g), seed yield (1.99 t/ha), and stover yield (2.18 t/ha) than 25 kg S/ha control. Arthanari [23] conducted an experiment during 2001 and 2002 at TNAU and concluded that application of 100% RDF through inorganic produced significantly higher head diameter, total number of seeds per head, shelling percentage, seed yield, oil yield and harvest index followed by 25% RDF through organic (FYM) + 75% through inorganic. Gudade*et al*. [24] conducted a field experiment at Oilseed Research Unit, Akola during *kharif* 2007-08 and concluded that application of 150% RDF produced higher seed yield with increase in yield of 28.07% and 15.36% over 50% and 100% RDFrespectively. Manjunatha*et al.*[25] found that the test weight in sunflower was significantly influenced by various treatments. FYM @ 7.5 t/ha + 100% RDF significantly and consistently increased the test weight (49.26 g) compared to control (36.62 g) except the treatment receiving FYM @ 7.5 t/ha + Jeevamrutha. Rani

et al.[3] observed that sulphur application at 60 kg/ha significantly and consistently increased the seed yield in sunflower over its lower levels and the magnitude of increase was 3.9, 7.1 and 34.0% over 40, 20 and 0 kg S/ha respectively. Akbari *et al.*[26] from their experiment at Iran during 2007 concluded that the highest grain yield (2823.3 kg/ha), maximum biological yield (9917.9 kg/ha) and oil yield per ha (1275.9 kg/ha) were attained in treatment of 50% N + 50% FYM which was statistically significant to other treatments of 75% N +25% FYM and 25% N + 75% FYM whereas the highest oil content (49.4%) was recorded in the treatment 100%FYM.Pavani*et al*. [4] experimented about the effect of different levels of nitrogen and sulphur on growth and yield of sunflower at College Farm, Rajendranagar on slightly alkaline sandy loam soil and reported that application of 30 kg S/ha recorded significantly higher seed yield(2048 kg/ha) and stalk yield (4028 kg/ha) than 0 and 15 kg S/ha having seed and stalk yields of 1732, 3696 kg/ha and 1921, 3882 kg/ha for 0 and 15 kg S/ha respectively. Mollashahi [8] reported that application of 225 kg/ha nitrogen produced maximum seed yield (1825 kg/ha), biological yield (1519.33 kg/ha) and oil content (41.90%) and were significantly higher than control. Rasool*et al*.[7] reported that higher yield attributing characters were observed at 20 t FYM/ha as compared to control. Number of filled achenes/ capitulum, 1000 seed weight, sterility percentage, achne yield and oil yield of 364, 60.08 g, 8.83%, 2.51 t/ha and 1.02 t/ha respectively which was higher than control. Rasool*et al*. [7] studied the effect of sulphur on yield attributing characters of sunflower and observed that the head diameter, test weight and filled achenes/capitulum increased significantly with application of 60 kg S/ha over 30 kg S/ha. The oil content and oil yield increased by 3% and 13.6% during 2009 and 2.4% and 10% during 2010 respectively with 60 kg S/ha over 30 kg S/ha. Gajbhiye*et al.*[5] studied the effect of nutrient management on growth and nutrient uptake in sunflower crop during *rabi*2010 at Latur and concluded that application of 150% RDF recorded maximum number of filled seeds per plant (733.56), number of unfilled seeds per plant (57.90), seed yield (1748 kg/ha), stalk yield (4279 kg/ha), harvest index (29.42%) and oil yield (686.1 kg/ha) over control. Thakur *et al*.[6] conducted a field experiment on sandy loam soil during *kharif*2012 at Rajendranagar and revealed that application of RDF + 12.5 kg/ha humic acid granules recorded significantly higher head diameter (20.7 cm), test weight (51.9 g), number of filled seeds per head (799), seed filling % (85.2%), seed yield (1875 kg/ha), stalk yield (4677 kg/ha), harvest index (28.7%) and oil content (43.9%) over RDF. Banerjee *et al.* [9] reported that application of $N_{100}P_{50}K_{50}$produced higher seeds per capitulum (1129.33), seed weight per capitulum (64.41 g), 100 seed weight (5.73 g) and seed yield (1465.15 kg/ha) which was statistically at par with 100% RDF ($N_{80}P_{40}K_{40}$) and significantly differed from farmers fertilizer practice ($N_{60}P_{30}K_{30}$).Pujar*et al.*[10] depicted that application of 30 kg S/ha + sulphur oxidizing biofertilizer produced higher head diameter (14.96 cm), head weight (343.33 g), seed weight/plant (88.74 g), 100 seed weight (4.98 g), seed yield (2007 kg/ha), stalk yield (2546 kg/ha), oil content (39%) and oil yield (783 kg/ha). Tahir *et al*.[11] reported that application of 4 kg B/ha recorded the highest number of seeds/head (1182.80), 1000 seed weight (70.38 g), seed yield (2.66 t/ha) and biological yield (12.25 t/ha) with corresponding values of 913.8, 55.47 g, 2.3 t/ha and 10.13 t/ha over control respectively. Biswas and Poddar [12]conducted an experiment in three consecutive *rabi* seasons during 2011-12 to 2013-14 at West Bengal and found that application of N @ 125 kg/ha + 40 kg S/ha recorded higher seed yield (2079 kg/ha) which was 29% higher than N @ 50 kg/ha + 0 kg S/ha. Buriro *et al.*[13] observed that application of PM @ 6 t/ha + 75% recommended dose of NPK produced higher seeds/head (1650.91), seed weight/head (66.04 g), seed yield (2017.74 kg/ha) and oil content (44.34%) which was at par with PM @ 8 t/ha + 50% recommended dose of NPK with corresponding values of 1648.51, 65.94 g, 1997.60 kg/ha and 44.14% respectively. Debina *et al*. [14] delineated that application of soil test based target yield NPK + 5 t FYM/ha + *Trichoderma viride* resulted in maximum seed yield (2367 kg/ha) and oil yield (970 kg/ha) which was followed by 150% NPK having values of 2315 kg/ha for seed yield and 955 kg/ha for oil yield, while control recorded lowest value (861 and 351.8 kg/ha for seed and oil yield respectively). Pattanayak *et al.* [15] in his experiment during 2014 stated that higher number of total seeds per capitulum (970.2) and filled grain/capitulum (890.0) were obtained with application of RDF + Boron @ 1 kg/ha and the lowest was obtained with RDF alone having corresponding values of 676.8 and 562.3 respectively. The lowest number of unfilled grain (80.2) was recorded in RDF + Boron @ 1 kg/ha than RDF (110.5). Number of unfilled grains was 37.78% higher in RDF than application of RDF + Boron @ 1 kg/ha. Choudhary*et al*. [17] concluded that application of 45 kg sulphur/ha + sulphur oxidizing biofertilizer recorded significantly higher head diameter (15.32 cm), head weight (351.18 g), seed yield (2372.66 kg/ha), stover yield (3117.00 kg/ha), harvest index (43.21%) and oil content (39.05%) than control (0 kg S/ha). Kalaiyarasan *et al.* [27] concluded that P_2O_5 at 100 kg/ha produced highest seed yield (2048 kg/ha), stalk yield (4379 kg/ha), oil content (43.49%) and oil yield (891 kg/ha). The lowest value was recorded with P_2O_5at 0 kg/ha with corresponding values of 973 kg/ha, 2692 kg/ha, 39.01% and 380 kg/ha respectively. Ravishankar *et al*.[16] revealed that application of 126 kg N/ha and 90 kg P_2O_5/ha with N/P fertilizer ratio of 1.40 depicted significantly higher head diameter (15.90 cm), test weight (63.01 g), seed yield (2650 kg/ha), seed oil content (40.50%) and oil yield (1074 kg/ha) when compared to control with corresponding values of 12.00 cm, 37.77 g, 1539 kg/ha, 35.77% and 554 kg/ha respectively. Kumar *et al.* [18] carried out an experiment at Jhansi and stated that application of 50% RDF + FYM @ 2.5 t/ha and

Azotobacter(seed treatment) registered maximum number of siliqua per plant (199.0), number of seed per siliqua (11.82), test weight (6.02 g) and seed yield (15.82 q/ha) over control with corresponding values of 167.0, 9.24, 5.34 g and 11.56 q/ha respectively. Adhikary *et al*. [19] delineated that higher seeds/ capitulum (972.14), seed weight/ capitulum (5.74 g), 100 seed weight (5.84 g) and seed yield (1723.27 kg/ha) were observed under application of 125% RDF ($N_{100}P_{50}K_{50}$) than N omission treatment. Dambale *et al.* [20] revealed that application of 100% RDF + FYM @ 5 t/ha attributed higher number of filled seed/plant (89.78%), seed yield (1866 kg/ha), stalk yield (5345 kg/ha) and oil yield (697 kg/ha) which was at par with 100% RDF + SR @ 5 t/ha and 100% RDF + SR @ 2.5 t + FYM @ 2.5 t/ha and the lowest value was obtained with SR @ 5t/ha. Mehmood *et al.* [21] revealed that application of Boron 2 kg/ha + nitrogen 150 kg/ha produced maximum head diameter (21.26 cm), economic yield(3870kg/ha) and biological yield(15846kg/ha)while minimum values of 14.43 cm, 2949 kg/ha and 11779 kg/ha for head diameter, economic yield and biological yield respectively were obtained with control (0 kg B + 0 kg N/ha). Kumar *et al.* [18] revealed that maximum seed yield (1859 kg/ha), oil yield (741 kg/ha) and protein yield (224 kg/ha) were found with the application of RDF (60-60-30 N, $P_2O_5$and K_2O kg/ha) + compost @ 5 t/ha and the lowest oil yield, protein yield and seed yield were obtained with control.

Effect of integrated nutrient management on nutrient uptake and available soil nutrientstatus

Rathiya [28] from a field experiment at Raipur found that conjunctive use of organic (CDM/PM) and inorganic sources of nutrients resulted in higher total N, $P_2O_5$and K_2O removal by sunflower crop at harvest. The soil available nitrogen, phosphorus and potassium status was also improved by applying integrated use of nutrients. Shekhawat and Shivay [22] found that increased levels of S and B improved the uptake of N, S and B significantly in the seed, stover and as well as total, whereas P uptake remained unaffected at both the doses of S and B. Uptake of K increased with increase in levels of S and B, resulting in increased total uptake. In a field experiment conducted by Gudade *et al*. [24] at Oilseed Research Unit, Akola revealed that application of 150% RDF recorded higher N, P and K uptake which were 42.93, 30.74 and 21.72% higher than 50% RDF. Rasool *et al.* [7] reported that uptake of nutrients increased with increase in application of N and S in sunflower. The lowest uptake (54.84 kg N/ha and 11.38 kg S/ha) was obtained from treatment combination of 40 kg N/ha + 30 kg S/ha + 0 t FYM/ha and the highest uptake (112.6 kg N/ha and 16.62 kg S/ha) was found with treatment combination of 120 kg N/ha + 60 kg S/ha + 20 t FYM/ha. Gajbhiye *et al.* [5] observed that uptake of N, P, K, S and B were reported maximum i.e. 47.36, 31.08, 98.86, 30.45 and 7.57 kg/ha respectively with application of 150% RDF over rest of the treatments whereas the lowest values were obtained in control with corresponding values of 28.11, 17.26, 42.94, 18.03 and 3.57 kg/ha respectively. Thakur *etal*. [6]concluded that RDF+ soil application of humic acid@ 12.5 kg/ha recorded significantly higher N, P and K uptake by seed and stalk i.e. 39.7 and 45.6 kg/ha for nitrogen, 6.8 and 13.7 kg/ha for phosphorus and 16.5 and 49.0 kg/ha forpotassiumrespectivelyoverRDFalonehavingcorrespondingvaluesof21.4and 28.9 kg/ha for N, 3.9 and 9.1 kg/ha for P and 9.1 and 26.9 kg/ha for K respectively. Banerjee *et al.* [9] reported that application of $N_{100}P_{50}K_{50}$recorded maximum nutrient uptake (68.75, 14.47 and 79.12 kg N, P and K/ha respectively) which was statistically at par with 100% RDF ($N_{80}P_{40}K_{40}$). Pujar *et al.* [10] observed that application of 30 kg S/ha + sulphur oxidizing biofertilizer reported significantly higher N (112.33kg/ha), P (23.57 kg/ha), K (86.91 kg/ha) and S uptake (13.08 and 15.81 kg/ha at 80 DAS and harvest respectively) which was 66%, 61%, 62% and 54% higher than control respectively. Biswas and Poddar [12] conducted an experiment during three consecutive *rabi* seasons from 2011-12 to 2013-14 at West Bengal and concluded that highest total nitrogen uptake was obtained at 75 kg N/ha and 40 kg S/ha. Highest potassium and sulphur uptake was obtained at 100 kg N/ha and 40 kg S/ha. There is a negative impact in phosphorus uptake when level of nitrogen was increased. Higher phosphorus uptake is obtained at 50 kg N/ha and 40 kg S/ha. Pattanayak *et al*. [15] in his experiment at Odisha University of Agriculture and Technology, Bubaneswar observed that maximum boron uptake was recorded with RDF + Boron @ 1 kg/ha (3634.74 mg/ha), which was significantly higher than RDF + ZnS04 @ 25 kg/ha (3339.1 mg/ha) and RDF alone (2301.02 mg/ha).Debina *et al.* [14] concluded that highest N (103 kg/ha), K (116 kg/ha) and S (12.8 kg/ha) uptake was found with application of soil test target yield NPK + B + 5t FYM/ha + *Trichoderma viride* which was at par with soil test based target yield NPK + Limiting micronutrient B while lowest was in control having 93 kg/ha, 97 kg/ha and 9.9 kg/ha for N, K and S uptake respectively. Kalaiyarasan *et al.* [27] revealed that the maximum N uptake (81.4 kg/ha), P uptake (23.52 kg/ha) and K uptake (72.5 kg/ha) was resulted from application of P_2O_5at 100 kg/ha while the lowest value was resulted from application of P_2O_5 at 0 kg/ha with corresponding values of 66.1 kg/ha, 14.17 kg/ha and 60.8 kg/ha respectively. In a field experiment conducted by Kumar *et al.* [18] at Rajendranagar, Hyderabad, it was revealed that application of RDF (60-60-30 N, $P_2O_5$and K_2O kg/ha) + compost @ 5.0 t/ha registered enhanced N uptake (35.82 and 33.72 kg/ha), P uptake (2.82 and 5.47 kg/ha) and K uptake (15.52 and 31.05 kg/ha) by seed and stalk at harvest respectively which was at par with application of RDF +

compost @ 2.5 t/ha while the lowest values were obtained by control with corresponding values of13.04 and 21.89 kg/ha; 0.87 and 2.90 kg/ha; and 5.10 and 17.09 kg/ha for N, P and K uptake by seed and stalk respectively. Adhikary *et al*. [19] observed that the total N, P and K uptake (67.02, 15.39 and 71.55 kg/ha respectively) was found highest with 125% RDF followed by 100% RDF, and superior to all other treatments.

Economics

Byrareddy *etal*.[1]reported that the highest B:C ratio of5.9wasobtainedwith the application of RDF + FYM @ 8 t/ha followed by 50% N (VC) + 50% N (urea) + (SSP) having B:C ratio of 5.8,while the least B:C ratio of 1.7 was recorded with control. Rasool *et al.* [7] concluded that application of 120 kg N/ha gave higher net return (Rs. 53797/ha) and B: C ratio (2.1) than 80 kg N/ha which have net return of Rs. 50498/ha and B: C ratio of 2.0. Similarly, 60 kg S/ha resulted in higher net return (Rs. 49115/ha) and B: C ratio (1.9) than 30 kg S/ha with corresponding values of Rs. 44867/ha and 1.8 respectively. Thakur *et al.* [6] revealed that maximum gross return (Rs. 69852/ha), net return (Rs. 49116/ha) and B:C ratio (3.3) were found with application of RDF + humic acid granules @ 12.5 kg/ha whereas lowest was recorded with control (Rs. 51178/ha, Rs. 31317/ha and 2.5 respectively) and RDF + FYM @ 5 t/ha (Rs. 55177/ha, Rs. 32116/ha and 2.3 respectively). Ullasa *et al.* [29] carried out a field experiment to standardize the best management practices for higher yields in sunflower at GKVK, Bengaluru and stated that maximum gross return (Rs. 73931/ha), net return (Rs. 51450/ha) and B:C ratio (3.29) were registered due to application of FYM (5 t/ha) and 100% RDF at plant population level of 74074 plants/ha. Banerjee *et al.* [9] concluded that net income increased till the highest dose (125% RDF), but the B: C ratio increased till 100% RDF and then decreased a bit at 125% RDF. Pujar *et al.* [10] observed that application of 30 kg S/ha + sulphur oxidizing biofertilizer reported significantly maximum gross returns (Rs.72252/ha), net returns (Rs. 46191/ha) and B:C ratio (2.77) as compared to other treatments. Debina *et al.* [14] reported that higher gross return of Rs. 142770/ha, net return of Rs. 87517/ha and B:C ratio of 2.58 were recorded with application of 150% RDF which was 64.4%, 48.2% and 71.7% higher than control. Ravishankar *et al.* [16] reported that application of 126 kg N/ha and 90 kg P_2O_5/ha with N/P fertilizer ratio of 1.40 resulted in significantly higher net return (Rs. 43940/ha) and B:C ratio (2.59) than control which had net return of Rs. 18910/ha and B: C ratio of1.83. Dambale *et al*.[20] studied the effect of integrated nutrient management on growth and yield of sunflower (*Helianthus annuus* L.) and revealed that application of 100% RDF + FYM @ 5 t/ha recorded significantly highest gross monetary return (Rs. 70908/ha), net monetary return (Rs. 44638/ha) and B: C ratio (2.69) which was at par with application of 100% RDF + SR @ 5 t/ha and 100% RDF + SR @ 2.5 t/ha + FYM @ 2.5 t/ha whereas the lowest was associated with application of SR @ 5 t/ha. In his experiment during 2009 at Agronomic Research Area, University of Agriculture Faisalabad, Pakistan, Mehmood *et al.* [21] revealed that variety Hysun- 33 with 2 kg B + 150 kg N/ha recorded highest net income and B:C ratio of Rs. 88518/ha and 1.25 respectively whereas control gave the lowest net income and B:C ratio of Rs. 60215/ha and 0.97 respectively.

Conclusion

Chemical fertilizers along with organics and secondary and micro nutrients resulted in increased growth, yield, nutrient uptake, gross return, net return and B: C ratio in sunflower. Integrated nutrient management resulted in increased monetary returns as well as increased soil health in a sustainable way.

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