Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(4): 2898-2901
Received: 14-05-2018
Accepted: 18-06-2018

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Response of sunflower to different ratios of nitrogen, phosphorus, potassium fertilizer

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Abstract
The experiment was conducted during two consecutive *rabi* seasons of 2013 and 2014 at the Krishi Vigyan Kendra Farm, Ashokenagar, West Bengal, India to determine the effect of omitted nutrients on productivity of sunflower. The influence of nutrient omissions on the soil health was also determined. The results clearly indicated positive response of NPK fertilization to sunflower. Ample NPK (125% RDF) recorded maximum plant height (1.69 m), basal girth (9.08 cm) and capitulam diameter (17.15 cm) and differed significantly from other treatments. Nutrient omitted plots showed significant reduction in growth attributes over ample NPK ($N_{100}P_{50}K_{50}$). Sunflower plants produced higher yield attributes (972.14 seeds capitulum^{-1}, 75.74 g seed weight capitulum^{-1} and 5.84 g for 100 seed weight and seed yield (1723.27 kg ha^{-1}) of sunflower under application of $N_{100}P_{50}K_{50}$. Actual balance of N in postharvest soil was positive in plots fertilized with 100% RDF ($N_{80}P_{40}K_{40}$) and P and K-omitted plots. There was actual gain of P status of post-harvest soil in all the treatments, except P-omitted plots. However, the actual balance of K was negative irrespective of treatments.

Keywords: sunflower, nutrient management, seed yield

Introduction
Sunflower (*Helianthus annuus* L.) is one of the most important oilseeds that contribute considerably to edible oil in the world with an intermediate water requirement. Sunflower is the fourth oilseed crop grown worldwide by area (Fagundes *et al.*, 2007). Because of its short duration life cycle, and photo and thermo insensitivity, the crop has wider adaptability in different agro-climatic regions and soil types. Sunflower has the ability to extract stored soil water in the deeper soil profile. Sunflower has well-developed and branched root system, and maintains open stomata under condition of high evaporation demands that usually prevail in hot arid and semi arid regions. Presently in India sunflower is grown over an area of 0.55 million hectares with a production of 0.42 million tonnes and a productivity of 753 kg ha^{-1} (Anon, 2016) [5] which is far below than its potential. The lower productivity is mainly due to lack of high yielding varieties, its cultivation on marginal lands with inadequate nutrients, non-adoption of proper crop rotation and weed management practices and also continuous use of inorganic fertilizer deteriorates soil health and also which makes soil unproductive for next season. Sunflower, being deep-rooted crop, is very much responsive to nutrients. Application of fertilizers having nutrients like nitrogen, phosphorous and potash can increase sunflower growth and yield substantially (Cechin & Fumis, 2004 and Sadras, 2006) [9, 21]. Nitrogen, phosphorus and potassium are the major plant nutrients essential for crop growth and development. Excess or deficiency of any one of these nutrients can cause excessive or stunted growth, leaving plants vulnerable to attack from various diseases and pests (Bakht *et al.*, 2010) [6]. Role of plant nutrients is of paramount importance, and balanced use of fertilizer could be one of the options to increase nutrient use efficiency (NUE). Nitrogen is the most important nutrient, which determines the growth of the oilseed crops and increases the amount of protein and the yield. Furthermore, N fertilizer application affects dry matter production as well as N accumulation and partitioning into various parts of crop plants for the growth, development and other processes (Khaliq and Cheema, 2005) [14]. Phosphorus is the second major nutrient after nitrogen in limiting the sunflower production as phosphorus is more prone for fixation rendering it as non-available to plants due to many soil reactions and interactions with other elements. Differential influence of N/P fertilizer ratios with same and different levels of nitrogen and phosphorus exists with respect to the crops, varieties and climate (NAAS, 2009) [17]. Application of K fertilizer was found to be particularly effective with respect to yield formation in sunflower (Amanullah and Khan, 2011) [4]. Phosphorus and potash are known to be efficiently utilized in the presence of nitrogen.

It promotes flowering, setting of seeds and increases the yield in oilseed crops (Bharose *et al.*, 2011) [7]. Therefore, nutrient management in sunflower assumes importance for increasing productivity. The present study was conducted to understand the response relationship between nutrients and sunflower yield is essential for its judicious management especially for the resource poor farmers of the region.

Materials and Methods

The experiment was conducted during two consecutive *rabi* seasons of 2013 and 2014 at the Krishi Vigyan Kendra Farm, Ashokenagar (latitude: 22° 50' 9.6324'' N, longitude: 88° 38' 13.8192'' E and altitude: 10.47m) West Bengal, India. This soil was medium in organic carbon content (0.67%) and the available nutrient status was low in nitrogen, medium range of phosphorus and the potassium status was high with neutral to alkaline in soil reaction. The variety used in this experiment was ‘‘PAC 361”. The treatments comprised of five NPK doses viz. T1: State recommendation (SR) or 100% RDF ($N_{80}P_{40}K_{40}$), T2: 125% RDF ($N_{100}P_{50}K_{50}$), T3: 125% NK ($N_{100}P_0K_{50}$), T4: 125% NP ($N_{100}P_{50}K_0$), and T5: 125% PK ($N_0P_{50}K_{50}$) were laid out in a randomized complete block design (RCBD) with four replications. Urea, single super phosphate (SSP), and muriate of potash (MOP) were used as a source of N, P and K, respectively. Half dose of N with full dose of P and K were applied as basal, rest 50% N was top-dressed at 30 days after sowing (DAS). All the other recommended agronomic and plant protection measures were adopted to raise the crop and the intercultural practices were taken as need based. The growth and yield related characters of sunflower, nutrient (N, P, and K) uptake in plants and available nutrient (N, P and K) status of post-harvest soil were subjected to analyzed following analysis of variance (ANOVA) technique and mean differences were adjusted by the multiple comparison test (Gomez and Gomez 1984) [11].

Result and Discussion

Growth attributes

The experimental data revealed that the application of inorganic sources of nutrients in different combinations induced marked variation in growth attributes of sunflower (Table 1). 25% higher doses of nutrient (T2) than RDF significantly influenced the plant height, stem girth as well as capitulam diameter in sunflower. The highest plant height was recorded in T2 followed by the RDF (T1) of nutrient. Yadav *et al.*, (2009) [24] also registered maximum plant height and other growth attributes with 125% (RDF, $N_{100}P_{50}K_{50}$, respectively). Whereas, the lowest plant height was noted in T5 treatment might be due to no application of nitrogen. Cechin and Fumis (2004) [9] also found that the sunflower height and shoot dry matter in better available N-grown plants were significantly higher compared to less available N-grown plants. High NPK doses might have extended the growth period and thus increased plant height (Sadiq *et al.*, 2000) [20]. Stem girth and capitulam diameter followed the similar trend being maximum in T2 treatment followed by T3 and the lowest value of these parameters was recorded in T5 treatment. Siddiqui *et al.* (2009) [22] also recorded tallest plant height and maximum stem girth under application of $N_{90}P_{45}K_{45}$ in sunflower cv. HO-1.

Yield attributes and yield

Application of different levels of nutrient markedly influence the yield attributes and yield except 100 seed weight. Nutrient omitted plots showed marked reduction in yield attributes such as seeds capitulam^{-1}, seed weight capitulam^{-1}, and seed yield (Table 2). The present study revealed that all the yield attributes as well as yield were highest with ample supply of nutrient doses. Maximum yield was obtained with T2 fertilizers level which was statistically at par with RDF (T1 fertilizers levels), while zero-N (125% PK) gave significantly less seeds capitulam^{-1}, seed weight capitulam^{-1} and substantially reduced the yield. These results substantiate the findings of Rondanini *et al.* (2007) [19] and as well as Cantagallo *et al.* (2009) [8] who also reported that the shortage of N affects the development and growth of both source and sink, and the number of seeds capitulam^{-1}. Omission of nutrients from ample NPK treatment caused variable reduction in yield attributes and yield (Table 2). In comparison with ample NPK treated plot, the magnitude of reduction due to N omission was to the tune of 36.79, 59.39, 7.87 and 30.72% for number of seeds capitulam^{-1}, seed weight capitulam^{-1}, 100 seed weight and seed yields, respectively. Whereas, in case of P and K omitted plots the extent of reduction was much less (P omitted plot: 6.26, 17.84, 3.6 and 5.87% for number of seeds capitulam^{-1}, seed weight capitulam^{-1}, 100 seed weight and seed yields, respectively; and K omitted plots: 14.47, 40.06, 5.14 and 14.0% for number of seeds capitulam^{-1}, seed weight capitulam^{-1}, 100 seed weight and seed yields, respectively). Higher seed yields with high rates of N were associated with an increase in seed number capitulam^{-1}, which ultimately leads to higher seed weight capitulam^{-1}. Higher seed yield of sunflower with increasing N rates is attributed to higher head diameter and seed weight (Abdel-Motagally and Osman, 2010) [2].

Nutrient uptake and nutrient balance

The increased uptake of major nutrients is primarily responsible for improved growth characters and yield attributes culminating into increased seed yield (Krishnamurthy *et al.*, 2011) [16]. Increasing levels of NPK application had positive influence on the total uptake of various nutrients by sunflower. The total N, P and K uptake was found maximum with 125% RDF followed by 100% RDF, and superior to all other fertility treatments (Table 3). The lowest uptake N (24.57 kg ha^{-1}), P (6.13 kg ha^{-1}) and K (19.57 kg ha^{-1}) were noted in N ($N_0P_{50}K_{50}$), P ($N_{100}P_0K_{50}$) and K ($N_{100}P_{50}K_0$) omitted plots respectively. Present study shows that nutrient status of the post-harvest soil was also influenced by various levels of NPK application. Available N, P, and K status of post-harvest soil was higher in plots receiving $N_{100}P_0K_{50}$, $N_{100}P_{50}K_{50}$ and $N_{80}P_{40}K_{40}$ nutrients respectively. There was apparent loss of N, P and K in all the plots under study except the plot receiving $N_0P_{50}K_{50}$ nutrients (Table 4). Actual balance of N was positive in plots fertilized with $N_{80}P_{40}K_{40}$, $N_{100}P_{50}K_0$ and $N_{100}P_0K_{50}$. This could be attributed to the fact that there is a synergistic effect i.e. positive interaction between N and P, and N and K uptake (Zubillaga *et al.*, 2002) [25]. Whereas, the actual balance of P was positive in all the plots except the P omitted plot ($N_{100}P_0K_{50}$). However, the actual balance of K was negative which means there was actual loss of K content in post-harvest soil, irrespective of treatments. This clearly explains that amount of K utilized by the sunflower crop was much higher than that of applied through fertilizer. The relationship between nutrient uptake and yield more clearly pointed out the effects of N and K on yield (fig 1). K helps in translocation of photosynthates from source to sink. This might be the possible reason of actual balance of K was negative irrespective of treatments as well as the strong positive relation (R^2 = 0.966) with yield.

The present investigation showed that the growth attributes as well as yield attributes were significantly increased with 25% increase of RDF ($N_{80}P_{40}K_{40}$) for sunflower in new alluvial zone of West Bengal. Although all the three primary nutrients had the effect on growth and yield attributes but the effects of N and K were more prominent on yield of sunflower. Omission of nutrients markedly influences the characters as well as uptake of nutrients by the crop.

Table 1: Effect of different treatment combinations of NPK fertilizers on growth attributes of sunflower

Treatment	Plant height (m)	Basal Girth (cm)	Capitulam Diameter (cm)
N:P:K::80:40:40	1.27	6.25	11.5
N:P:K::100:50:50	1.69	9.08	17.15
N:P:K::100:0:50	1.17	7.20	13.25
N:P:K::100:50:0	1.01	5.30	9.25
N:P:K::0:50:50	0.68	4.03	5.70
S.Em(±)	0.043	0.376	0.527
C.D.(p=0.05)	0.13	1.171	1.64

Table 2: Effect of different treatment combinations of NPK fertilizers on yield attributes and yields of sunflower

Treatment	Seeds Capitulam^{-1}	Seeds weight Capitulam^{-1}	100 seeds weight (g)	Yield Kg ha^{-1}
N:P:K::80:40:40	931.75	51.51	5.35	1,658.50
N:P:K::100:50:50	972.14	75.74	5.84	1,723.27
N:P:K::100:0:50	911.25	62.23	5.63	1,622.11
N:P:K::100:50:0	831.50	45.40	5.54	1,482.07
N:P:K::0:50:50	614.50	30.76	5.38	1,193.81
S.Em(±)	9.163	0.798	0.14	22.306
C.D.(p=0.05)	28.546	2.485	NS	69.494

Table 3: Nutrient uptake in sunflower and available nutrient status of post-harvest soil as influenced by different treatment combinations of NPK fertilizers

Treatment	Nutrient uptake (kg ha^{-1})			Available nutrient status (kg ha^{-1})		
	N	P	K	N	P	K
N:P:K::80:40:40	43.89	10.22	54.23	179.32	40.33	73.37
N:P:K::100:50:50	67.02	15.39	71.55	161.96	48.21	67.81
N:P:K::100:0:50	39.13	6.13	34.92	185.21	14.29	64.97
N:P:K::100:50:0	33.28	10.21	19.57	183.12	45.07	56.22
N:P:K::0:50:50	24.57	7.82	33.49	166.89	45.33	63.33

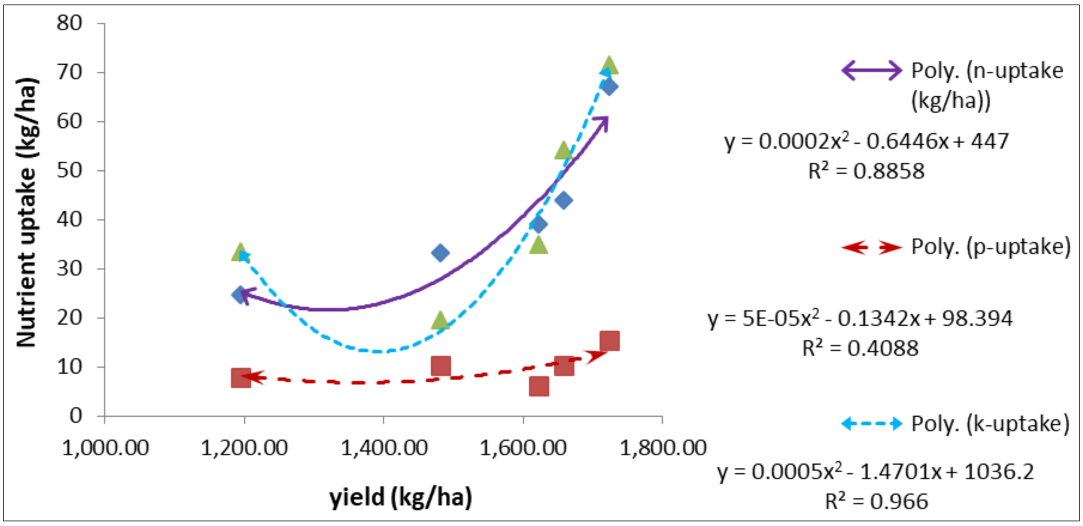

Fig 1: Relationship between nutrient uptake and yield

Table 4: Balance sheet for N, P and K as computed after harvest of sunflower crop

Treatment	Initial soil nutrient Status (a)	Nutrient added Through fertilizer (b)	Total Nutrient (c = a + b)	Crop uptake (d)	Expected balance (e) = (c - d)	Actual Balance (f)	Apparent gain/ loss (g) = (f-e)	Actual gain/ loss h = (f-a)
Nitrogen								
T1	174.36	80	254.36	43.89	210.47	179.32	-31.15	4.96
T2	174.36	100	274.36	67.02	207.34	161.96	-45.38	-12.4
T3	174.36	100	274.36	39.13	235.23	185.21	-50.02	10.85
T4	174.36	100	274.36	33.28	241.08	183.12	-57.96	8.76
T5	174.36	0	174.36	24.57	149.79	166.89	17.10	-7.47

Phosphorus								
T1	33.26	40	73.26	10.22	63.04	40.33	-22.71	7.07
T2	33.26	50	83.26	15.39	67.87	48.21	-19.66	14.95
T3	33.26	0	33.26	6.13	27.13	14.29	-12.84	-18.97
T4	33.26	50	83.26	10.21	73.05	45.07	-27.98	11.81
T5	33.26	50	83.26	7.82	75.44	45.33	-30.11	12.07
Potassium								
T1	145.89	40	185.89	54.23	131.66	73.37	-58.29	-72.52
T2	145.89	50	195.89	71.55	124.34	67.81	-56.53	-78.08
T3	145.89	50	195.89	34.92	160.97	64.97	-96.00	-80.92
T4	145.89	0	145.89	19.57	126.32	56.22	-70.10	-89.67
T5	145.89	50	195.89	33.49	162.4	63.33	-99.07	-82.56

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