Nutrient uptake, post-harvest soil nutrient status and economic returns from sunflower (*Helianthus annuus* L.) hybrids under different tillage and nutrient levels on lowland rice fallow environments of Odisha

ANITA MAHAPATRA*, DIKSHA PATEL, KULASEKARAN RAMESH1 AND B GOUDA

Odisha University of Agriculture and Technology, Bhubaneswar-751 003, Odisha

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ABSTRACT

A field experiment was conducted at College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar on sandy loam soils during summer season of 2019 to study the effect of varied nutrient doses and tillage on the nutrient uptake and economics of sunflower (*Helianthus annuus* L.) hybrids under lowland rice fallow environments. Three sunflower hybrids *viz.,* DRSH-1, KBSH-44 and MSFH-17 were tested under three graded fertility levels RDF (recommended dose of fertilizers), 50% RDF (30: 40: 30 kg N: P_2O_5: K_2O /ha), 100% RDF (60: 80: 60 kg N: P_2O_5: K_2O /ha) and 150% RDF (90:120:90 kg N: P_2O_5: K_2O/ha) and four tillage practices *viz.,* reduced, minimum, zero tillage and conventional tillage practice. Sunflower under zero tillage recorded the highest uptake of N (52.65 kg /ha), P (21.87 kg/ha) and K (76.03 kg/ha) besides highest seed yield (1.91 t/ha). On the other hand, conventional tillage recorded the highest post-harvest soil available nitrogen (216.6 kg /ha), phosphorous (12.9 kg/ha) and potassium (214.4 kg/ha). Among the hybrids, KBSH-44 recorded significantly higher seed yield (1.81 t/ha) besides highest nutrient uptake. Raising sunflower hybrid KBSH-44 under rice fallow zero tillage conditions and fertilized with 150% RDF (90:120:90 kg N: P_2O_5: K_2O/ha) was found economically superior in terms of gross returns, net returns and B: C ratio (2.34).

Keywords: Nutrient uptake, RDF, Rice fallow, Sunflower hybrid

Oilseeds play an important role in agricultural economy of India. Oilseeds are important next only to food grains in terms of area, production and value. Sunflower ranks third in total area and fourth in the total production among major oilseed crops in the world i.e. soybean, *Brassica*, sunflower and groundnut. Its oil is of premium quality with high level of poly unsaturated fatty acids (PUFA) which is good for heart patients. Presently sunflower is cultivated worldwide on an area of 27.3 m ha with a productivity of 1.82 t/ha. In India, area under sunflower is 3.81 lakh ha with a production of 2.51 lakh tonnes. In Odisha, it is cultivated in an area of 24.88 thousand hectares with production and productivity of 29.69 thousand metric tonnes and 1193 kg/ha, respectively. Rice fallow areas are the potential regions for horizontal expansion of oilseeds to utilize the residual soil moisture and nutrients (Ramesh *et al*., 2020). Sunflower can serve as an ideal catch crop during the period when land is left fallow after *kharif* rice with 150 days duration which is harvested during November-December (Ramesh *et al.,* 2019). In Odisha, rice fallow includes all the three rice ecosystems *viz.,* upland, medium as well as low lands, which are kept fallow during *rabi* season after harvest of *kharif* paddy to the tune of 12.2 lakh ha spread over all the thirty districts due to multitude of reasons. Although sunflower is cultivated in few pockets with supplemental irrigation, improved package of practices are needed to boost the productivity.

[1]ICAR-Indian Institute of Oilseeds Research, Hyderabad-500 030, Telangana;
*Corresponding author's E-mail: anita.mahapatra100@gmail.com

Tillage plays a major role under rice fallow environments. While conservation agriculture is a cultivation practice encompassing nil disturbances to the land (Ramesh *et al*., 2021) through conservation tillage to control erosion, reduce soil compaction, improve soil physical properties and retention of moisture and thereby improve land productivity. Nutrient supply has a great influence on crop grain yield (Mohammadi *et al.,* 2011) and the yields of hybrids are better than varieties due to high nutrient uptake (Sheoran *et al*., 2016). Sunflower crop responds to nutrients because of its deep root system. Balanced fertilization favourably influences seed yield (Ramesh *et al.,* 2017; Patel *et al.,* 2020). Conservation tillage places greater emphasis on environment, soil organic carbon storage, minimizing tillage expenses and so on. Understanding the best tillage practice, fertilizer management for a particular hybrid is a critical component of such rice fallow situations. Appropriate tillage practices with balanced application of fertilizers for a suitable hybrid would result in a greater level of productivity, nutrient uptake and a higher economic benefit than if management practices were solely based on the non-rice fallow systems. Keeping these points in view, the present experiment was conducted to examine the effect of different tillage practices and fertility management on productivity and nutrient uptake of summer sunflower hybrids in rice fallow environments of Odisha.

The experiment was conducted at Agronomy Main Research Farm, OUAT, Bhubaneswar during the summer, 2019. The research farm is geographically located at 200

12'N latitude and 850 52' E longitudes at an altitude of 25.9 m above mean sea level. The soil of the experimental field was sandy loamy, slightly acidic (pH =5.5), low in organic carbon (0.34%), available N (200.0 kg/ha) and P_2O_5 (11.7 kg/ha) and medium in exchangeable K_2O content (210.0 kg/ha). The experiment was laid out in a split-split plot design, replicated thrice with four tillage management practices (M_1- Conventional, M_2 - Reduced, M_3 - Minimum and M_4 - Zero), in main plots, three genotypes (G_1- DRSH-1, G_2- KBSH-44 and G_3-MSFH-17 as (local check) in sub plots and three fertility levels F_1- 50% RDF (30 : 40 : 30 kg N : P_2O_5: K_2O/ha), F_2-100% RDF (60:80:60 kg N:P_2O_5:K_2O/ha), F_3-150% RDF (90:120:90 kg N:P_2O_5:K_2O/ha) in sub-sub plots. The gross plot size was 5.4 m×3.3 m (17.82 m^2) with a spacing of 60 cm x 30 cm. The land was prepared as per the tillage treatments, conventional tillage (2 plough fb 2 cultivator and 1 rotavator), reduced tillage (1 plough fb 1 cultivator and 1 rotavator), Minimum tillage (1 cultivator fb 1 rotavator) and zero tillage (Herbicide spray + seed dibbling) after harvest of the preceding rice crop. Well decomposed FYM @ 5t/ha was applied uniformly at the time of final land preparation. The fertilizer was applied as per the treatment i.e. 50% RDF (30: 40: 30 kg N: P_2O_5: K_2O/ha), 100% RDF (60: 80:60 kg N: P_2O_5: K_2O/ha) and 150% RDF (90: 120: 90 kg N: P_2O_5: K_2O/ha) through urea, single super phosphate and muriate of potash. Entire quantity of P was applied as basal whereas N was applied in three splits and K in two splits. Full dose of P + 50% N + 50% K was applied at the time of sowing. First topdressing was done at 30 DAS with 25% N + 50% K while the balance 25% N was top dressed at 45 DAS. Three Sunflower hybrids *viz*., DRSH -1, KBSH-44 and MSFH-17 (DRSH-1:100-105 days duration, yield potential 20-25 q/ha, oil content of 40-44%; KBSH-44: 95-100 days duration, yield potential 17.5-28 q/ha, oil content 36-38 %; MSFH-17 :85-88 days duration, yield potential 13-16 q /ha, oil content 35-37%) were sown @ 5 kg/ha in line by maintaining 60 cm row to row and 30 cm plant to plant distance, at a depth of 3-4 cm on 31.12.2018. For weed management in zero tillage plots, glyphosate @1.0 kg a.i./ha was sprayed after harvest of rice followed by pre-emergence spray of pendimethalin @ 1.0 kg/ha. For other tillage practices two hand weeding were done at 20 and 40 DAS. During experimental period, a total of five irrigations were given uniformly. The crop was kept free from pests and diseases by taking up the need-based plant protection measures. The crop was harvested when back of the head (capitulum) turned to lemon yellow colour. Standard soil and plant nutrient analysis procedures were followed for nutrient uptake calculations and post-harvest nutrient status. Data were analysed statistically using the F-test (Gomez and Gomez, 1984). Critical difference (CD) values at 5% probability level were used for determining the significance of differences between the means.

Our experimental results, with respect to yield and economics of different treatments, indicated that zero tillage recorded significantly highest seed yield (1.91 t/ha) while conventional tillage gave the least seed yield of 1.63 t/ha. Significant increase of seed yield in no tillage over conventional tillage was also reported earlier by Sapkota *et al*. (2014). Enhanced yield in conservation tillage was because of the associated factors like residual nutrients from the preceding rice crop, resistance against soil degradation, soil moisture and fertility improvements, reduced evaporation loss and improved water infiltration as well as less soil and wind erosion as reported by Govaerts *et al.* (2011). Among the hybrids, KBSH-44 recorded significantly highest seed yield (1.81 t/ha) which was at par with DRSH-1 (1.73 t/ha). MSFH-17 gave least seed yield of 1.65 t/ha (Patel *et al.,* 2020). This might be due to the genetic potential of KBSH-44 to utilize the resources properly, translocate the photosynthates from source to sink and adaptability to agro-climatic condition. Pattanayak (2015) and Sheoran *et al*. (2016) observed similar findings. 150% RDF produced significantly higher seed yield of 2.09 t/ha followed by 100% RDF (1.75 t/ha). The treatment 50% RDF gave least seed yield (1.35 t/ha). The seed yield increased progressively with increasing level of fertilizer in all the hybrids as reported by Nasim *et al.* (2017). All the economic indices, gross return, net return and B:C ratio were influenced by tillage management, hybrids and fertility levels (Table 1). Maximum gross returns (₹1,02,709/ha), net returns (₹61,172/ha) and highest benefit- cost ratio of 2.48 were obtained under zero tillage. The lowest economic returns were obtained with conventional tillage. Out of three hybrids, KBSH-44 recorded the maximum gross return of ₹97,604/ha, higher net return of ₹55,720/ha and B:C ratio of 2.32 followed by DRSH-1. The hybrid MSFH-17 recorded significantly lowest gross return, net return and B:C ratio. Gross income, net income and B:C ratio continued to increase till 150% RDF.150% RDF registered the highest gross return of ₹1,12,786/ha, net return of ₹64,439/ha and benefit-cost ratio of 2.34 followed by 100% RDF (2.24), whereas 50% RDF recorded least gross return of ₹72,630/ha, net return of ₹36,233/ha and B: C ratio (2.01).

In terms of nutrient uptake, analysis of the results (Table 2) indicated significantly higher uptake of primary nutrients (52.65, 21.87 and 76.03 kg NPK/ha respectively) under zero tillage practice and lowest under conventional tillage (44.41, 17.79 and 64.03 kg/ha NPK respectively) apparently due to high seed yield (Patel *et al*., 2020). More N, P and K content and corresponding dry matter contributed for higher nitrogen uptake in zero tillage (Sridhar *et al*., 2012). Enhanced drymatter cum yield in conservation tillage may be because of the associated factors like resistance against soil degradation, soil moisture and fertility improvements, reduced evaporation loss as well as less soil and wind erosion as reported by Govaerts *et al.* (2011). Enhanced

nutrient uptake in zero tillage in comparison to conventional tillage might be due to enhanced soil moisture which facilitate better nutrient uptake by increasing biomass as reported by Sobhana (2017). The competitive ability of rice fallow crop systems is enhanced through readily available transformed nutrients from the carry over effect of rice fertilization is the key to success of rice fallow sunflower. Relative time of nutrient release and availability from the previous rice crop, for instance, is an important determinant of competitive ability, as an early acquisition of nutrients enhances growth and productivity from rice fallow crops. Among the hybrids, KBSH-44 resulted in the highest nitrogen and potassium uptake due to its high dry matter production and higher nutrient content in its dry matter and was followed by DRSH-1. Similar findings were reported by Kailash (2015) and Pattanayak (2015). Accumulation of total nitrogen (59.92 kg/ha), phosphorous (24.1 kg/ha) and potassium (85.56 kg/ha) in sunflower was highest under 150% RDF whereas lowest accumulation of 35.30, 14.5 and 53.36 kg/ha nitrogen, phosphorous and potassium respectively was recorded under 50% RDF. Increased total biomass with increasing nutrient application might be the reason for greater absorption of all the nutrients from the soil, which resulted in higher total uptake of various nutrients. This corroborated the findings of Dutta and Enghipi (2016) and Adhikary *et al*. (2018). The on par nutrient uptake between DRSH-1 and KBSH-44 might be due to on par dry matter accumulation.

Table 1 Influence of tillage, hybrid and fertility level on yield and economics of sunflower grown in paddy fallows

Treatment		Seed yield (t/ha)	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
	Tillage management					
M_1	Conventional	1.63	44729	87617	42889	1.93
M_2	Reduced	1.66	42238	89594	47356	2.10
M_3	Minimum	1.73	40710	93067	52357	2.27
M_4	Zero	1.91	41538	102709	61172	2.48
	SEm ±	0.035	-	-	-	-
	CD (0.05)	0.12	-	-	-	-
	Hybrid					
G_1	DRSH-1	1.73	42383	93292	50908	2.19
G_2	KBSH-44	1.81	41883	97604	55720	2.32
G_3	MSFH-17	1.65	42643	88845	46202	2.07
	SEm ±	0.035	-	-	-	-
	CD (0.05)	0.11	-	-	-	-
	Fertility level					
F_1	50% RDF	1.35	36397	72630	36233	2.01
F_2	100% RDF	1.75	42167	94325	52158	2.24
F_3	150% RDF	2.09	48347	112786	64439	2.34
	SEm ±	0.024	-	-	-	-
	CD (0.05)	0.07	-	-	-	-

The post-harvest soil status analysis indicated that the soil was more acidic (pH of 5.1) under zero tillage which remained at par with minimum tillage (Table 3). A soil pH of 5.7 was observed under conventional tillage. It has been observed earlier that surface soil becomes more acidic under conservation agriculture than conventional tillage (Sobhana, 2017). The lowering of pH under conservation agriculture has been attributed to build up of soil organic matter and release of organic acids upon decomposition in the surface layer (Singh *et al*., 2014). There was no significant difference in electrical conductivity of soil due to tillage practices (Sridhar *et al*., 2012). Significantly higher soil organic carbon of 0.40% was seen with zero tillage whereas the lowest organic carbon of 0.35% was found under conventional tillage. The results are in accordance with the findings of Meena (2010). Restriction of tillage under zero tillage condition improves the structure of the soil, especially micro aggregates, which is active site of holding labile C for longer periods. This led to higher labile C formation in soil. Highest soil available nitrogen (216.6 kg/ha) and phosphorous (12.9 kg/ha) was observed under conventional tillage (Table 3). Tillage practices could not influence the available soil potassium significantly. Similar results were reported by Gupta *et al.* (2011) and Sridhar *et al.* (2012). Minimum soil available nitrogen (204.8 kg/ha) and potassium (212.6 kg /ha) was where KBSH-44 was grown, whereas maximum soil available nitrogen (211.7 kg/ha), and potassium (214.6 kg/ha) was observed where MSFH-17 hybrid had been grown (Table 3). No significant difference was seen in available phosphorous status in soil, as uptake of nutrients by KBSH-44 was more as sunflower is a voracious feeder. Difference in available soil nutrients were also

reported by Kailash (2015). As anticipated, maximum soil available nitrogen (219.5 kg/ha), phosphorus (13.7 kg/ha) and potassium (218.0 kg/ha) were observed under 150% RDF (Table 3), whereas minimum soil available nitrogen, phosphorus and potassium were observed under 50% RDF. These observations were as repored earlier by Dutta *et al.* (2016) and Kalaiyarasan *et al.* (2017).

Table 2 Total nutrient uptake of sunflower as influenced by tillage practices, genotype and fertility levels

Treatments		Nutrient uptake (kg/ha)		
		Nitrogen	Phosphorus	Potassium
	Main Plot (Tillage)			
M_1	Conventional	44.41	17.79	64.03
M_2	Reduced	45.55	18.40	69.00
M_3	Minimum	47.63	19.08	70.62
M_4	Zero	52.65	21.87	76.03
	S.Em. ±	1.03	0.56	1.21
	CD(p=0.05)	3.44	1.87	4.04
	Sub Plot (Hybrid)			
G_1	DRSH-1	47.59	18.92	70.69
G_2	KBSH-44	50.37	19.79	72.72
G_3	MSFH-17	44.71	19.15	66.37
	S.Em. ±	0.56	0.54	0.73
	CD (p=0.05)	1.85	NS	2.40
	Sub-Sub Plot (Fertility Levels)			
F_1	50% RDF	35.30	14.5	53.36
F_2	100% RDF	47.46	19.2	70.86
F_3	150%RDF	59.92	24.1	85.56
	S.Em. ±	0.68	0.30	0.80
	CD (p=0.05)	2.00	0.90	2.35

* RDF- 60: 80: 60 kg N: P_2O_5: K_2O/ha

Table 3 Post-harvest soil pH, EC, Organic carbon and soil available nutrients as influenced by tillage practice, hybrid and fertility levels

Treatment		pH	Electrical conductivity (d/Sm)	Organic Carbon (%)	Soil available nutrients (k /ha)		
					Nitrogen	Phosphorus	Potassium
	Tillage management						
M_1	Conventional	5.7	0.25	0.35	216.6	12.9	214.4
M_2	Reduced	5.6	0.21	0.36	209.6	12.0	212.6
M_3	Minimum	5.3	0.20	0.37	204.7	12.3	211.5
M_4	Zero	5.2	0.23	0.40	202.1	11.8	211.3
	SEm ±	0.08	0.01	0.01	1.35	0.15	1.63
	CD (p=0.05)	0.3	NS	0.02	4.5	0.5	NS
	Hybrid						
G_1	DRSH-1	5.6	0.24	0.36	208.3	12.1	212.6
G_2	KBSH-44	5.4	0.23	0.41	204.8	12.1	210.2
G_3	MSFH-17	5.5	0.20	0.34	211.7	12.5	214.6
	SEm ±	0.07	0.01	0.004	1.34	0.16	0.84
	CD (p=0.05)	NS	NS	0.01	4.4	NS	2.7
	Fertility Level						
F_1	50% RDF	5.4	0.20	0.34	194.4	10.4	206.2
F_2	100% RDF	5.5	0.22	0.36	210.8	12.5	213.1
F_3	150%RDF	5.6	0.25	0.41	219.5	13.7	218.0
	SEm ±	0.06	0.01	0.003	1.44	0.14	1.58
	CD (p=0.05)	NS	0.01	0.01	4.2	0.4	4.6

* RDF- 60:80: 60 kg N: P_2O_5: K_2O/ha; Initial soil fertility: 200: 11.7: 210 kg N: P_2O_5: K_2O/ha

Zero tillage, the extreme form of conservation tillage during summer in rice fallows was found to be the optimum tillage practice for getting higher productivity of sunflower on sandy loam soils under the agro-climatic conditions of Bhubaneswar, Odisha. To no small extent, the success and sustainability of conservation tillage coupled with appropriate nutrient scheduling shapes the success and sustainability of rice fallow systems. Among the hybrids, KBSH-44 performed significantly better than existing hybrid MSFH-17 with high nutrient uptake.150% recommended dose of fertilizer gave highest nutrient uptake by the plants, gross return, net return and B:C ratio in sunflower. Growing of summer sunflower hybrids under zero tillage fertilized with 150% RDF (90:120:90 kg N:P_2O_5:K_2O/ha) could maximize the productivity under lowland rice fallow environments of Odisha.

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