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AGRONOMY

Effect of Intercropping Summer Sunflower (*Helianthus annuus* L.) with Legumes on Yield Attributes and Productivity of Crops

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ABSTRACT

Intercropping of Sunflower with Groundnut and Blackgram in different cropping patterns showing effects on yield attributes in sole crops and intercrops. In view of this a experiment was conducted during *summer* season (February to June) of 2018 at Bagusala Farm (23°39′ N latitude, 87°42′ E longitude) of M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi. Effect of intercropping summer sunflower with legumes on yield attributes and productivity. 9 treatments of sole, 1:1, 2:1, 3:1 ratios of sunflower[1] crop with groundnut[2] and blackgram[3] were tested in RCBD design with three replications. The experiment revealed that superior performance in expression of yield attributes like significantly increased the yield attributes like Number of pods/ capitulum per plant, Number of seeds per pods/capitulum, Number of seeds per plant, Seed weight per plant (g), 1000 seeds weight (g), Seed yield (kg/ha), Biological yield (kg/ha). It may be concluded that to obtain higher productivity of crops which are having higher productivity during summer season in sandy loam soils.

Highlights

- Intercropping in 1:1 ratio of sunflower and groundnut will be mostly suitable for south Odisha climatic conditions.
- The seed yield is also high in 1:1 ratio of sunflower and groundnut with 1495.7 kg/ha and also in sunflower and blackgram with 2:1 ratio gives seed yield 1467.6kg/ha.
- The crops with 1:1 ratio of sunflower and groundnut are giving higher monetary advantages, net returns and benefit cost ratio.

Keywords: Sunflower, Groundnut, Blackgram, Phosphorus, Capitulum, Yield, Productivity

The oilseeds scenario in the country has undergone a sea change in the last more than two decades. India changed from net importer in the 1980s to a net exporter status during early 1990s. In India, annual oilseeds are cultivated over 26.67 million hectares of area producing 30.06 million tonnes annually. Majority of the oilseeds are cultivated under rainfed ecosystem (70%). The area under oilseeds has experienced a deceleration in general, and this is due to their relative lower profitability against competing crops. India is one of the largest producers and consumers of edible oils and fats in the world. It is also the world's largest importer of edible oils but when compared with rest of the world per capita consumption in India is significantly lower due to various reasons such as high demand-supply gap, higher prices and low agricultural production of oil seeds. The per capita consumption of edible oil including *Vanaspati* is around 10 kg in recent years. Increase in per capita income pushes further

demand for oil significantly. Sunflower (*Helianthus annus* L.) is one of the three important edible oilseed crops grown in the world after soybean and groundnut. In India, it is an important source of edible and nutritious oil. It has been observed that in the world sunflower was grown in about 26.20 million hectares with a production of 47.34 million tonnes with an average productivity of 1806.7 kg ha^{-1}, (FAO, 2016). The major sunflower producing countries are Ukraine, Argentina, China, Romania, France, India, Hungary, USA and Spain. In India, sunflower is cultivated in 0.49 million hectares with a production of 0.30 million tons and productivity of 608 kg/ha. The major sunflower producing states are Karnataka, Bihar, Haryana, Andhra Pradesh, Haryana and others (Government of India, 2017). Odisha covers only 3.3% of sunflower area of the country, but productivity of this oilseed is quite high than the national average (1189 kg/ha). However, productivity is further increased as because a number of potential hybrids and high yielding varieties have been developed in the country. Cultivation of sunflower further offers ample scope of intercropping for maximum utilization of resources. Intercropping is the agricultural practice of cultivating two or more crops in the same space at the same time and sometimes referred as mixed cropping or polyculture (Andrews and Kassam 1976; Ofori and Stern 1987; Anil *et al*. 1998; Maitra *et al*. 2019). The two or more crops of preferably dissimilar types are grown in an intercropping system. There is no doubt that intercropping add value in cropping system by many ways like assuring more output, better utilization of resources and monetary advantage (Maitra *et al*. 2000; Manasa *et al*. 2018). Enough study has not been conducted on sunflower based intercropping system in south Odisha conditions; hence, an attempt has been taken through the present study to evaluate the efficiency of intercropping legumes in sunflower.

MATERIALS AND METHODS

The field experiment was carried out during the summer of 2018 (Feb- May) at Bagusala Farm, M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha on sandy loam soil, having a pH-6.1 and 230 kg ha^{-1} available nitrogen and 32.10 kg ha^{-1} available phosphorous and 346 kg ha^{-1} available potassium and medium in organic carbon content 0.73%. The experimental field was a medium land with good irrigation and drainage facilities. The experiment was conducted in a randomized completely block design. The experiment have nine treatments, viz., $\mathbf{C_1}$ – Sole Sunflower, $\mathbf{C_2}$ – Sole Black gram, $\mathbf{C_3}$ – Sole Groundnut, $\mathbf{C_4}$ – Sunflower + Black gram at 1:1 row ratio, $\mathbf{C_5}$ – Sunflower + Ground nut at 1:1 row ratio, $\mathbf{C_6}$ – Sunflower + Black gram at 2:1 row ratio, $\mathbf{C_7}$ – Sunflower + Ground nut at 2:1 row ratio, $\mathbf{C_8}$ – Sunflower + Black gram at 3:1 row ratio, $\mathbf{C_9}$ – Sunflower + Ground nut at 3:1 row ratio. In case of sunflower, commercial hybrid 'VSH 404' was chosen, however, K6 and PU31 were the varieties of groundnut and blackgram. Seeds of the crops were sown on 2nd February 2018 at a spacing of 45 cm × 30 cm for sunflower, 45 cm × 10 cm groundnut and 20 cm × 10 cm for black gram in their pure stand. In the replacement series of intercropping as per the treatment sunflower + legumes were sown. A fertilizer dosage of 60: 80: 60 kg of N: P_2O_5: K_2O ha^{-1} was applied to sunflower in the plots of sole crop and intercrops, however, 20:40:20 kg N: P_2O_5: K_2O ha^{-1} was applied to sole crop of legumes. 10 t well decomposed FYM, half N, full P_2O_5 and K_2O was applied as basal dose at the time of final land preparation. Rest amount of N (30 kg ha^{-1}) was splitted in to two, of which the first was applied at 30 DAS and the second was applied at 45 DAS to sunflower and intercropped treatments. However, in case of legumes both of the organic manures and chemical were applied as basal dose. Five irrigations were given during entire crop growth period. Rainfall received during the crop growth period was 12.73 cm. Observations on growth, yield and yield attributes were recorded, statistically analyzed and briefly discussed in the following paragraphs.

RESULTS AND DISCUSSION

Yield Parameters

Different cropping systems significantly influenced the number of capitulum $plant^{-1}$ (Table 1). The maximum number of capitulum $plant^{-1}$ (365.64) was recorded by the treatment C_8 (sunflower + black gram at 3:1 row ratio) which differed significantly with all other treatments. Treatment C_1 (sole sunflower) registered 322.67 number of capitulum $plant^{-1}$ which was statistically at par with treatment

Table 1: Yield attributes, seed yield, biological yield, oil content and oil yield of sunflower as influenced by intercropping systems

Treatments	Yield attributes and yield						
	Number of seeds capitulum^{-1}	Seed weight plant^{-1} (g)	1000 seeds weight (g)	Seed yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Oil content (%)	Oil yield (kg ha^{-1})
C_1 (sole S)	322.67	3.06	35.11	1833.0	4638.3	35.86	660.70
C_4 (S+BG 1:1)	283.34	2.90	27.90	1277.3	3606.4	35.97	459.92
C_5 (S+G 1:1)	265.00	2.84	27.26	1467.6	3798.3	39.43	578.85
C_6 (S+BG 2:1)	314.66	2.92	34.60	1495.7	3778.2	40.40	603.65
C_7 (S+G 2:1)	266.00	3.20	39.23	1259.3	3460.0	40.16	505.91
C_8 (S=BG 3:1)	365.64	3.14	35.34	1251	3530.0	35.93	450.29
C_9 (S+G 3:1)	223.32	2.59	36.76	1199.5	3511.5	37.90	453.61
S. Em. (±)	12.658	0.077	1.605	43.365	131.15	0.723	18.556
C.D. (*p=0.05*)	39.003	0.238	4.948	133.62	404.13	2.228	67.177
C.V. (%)	11.488	6.931	12.591	8.209	9.22	5.041	9.256

***C_1** – Sole Sunflower, **C_4** – Sunflower + Black gram at 1:1 row ratio,**C_5** – Sunflower + Ground nut at 1:1 row ratio, **C_6** – Sunflower + Black gram at 2:1 row ratio, **C_7** – Sunflower + Ground nut at 2:1 row ratio, **C_8** – Sunflower + Black gram at 3:1 row ratio, **C_9** – Sunflower + Ground nut at 3:1 row ratio.*

C_6 (sunflower + black gram at 2:1 row ratio). The lowest number of capitulum plant^{-1} (223.32) was recorded by C_9 (sunflower + groundnut at 3:1 row ratio). Seed weight plant^{-1} (g) of sunflower was significantly influenced by cropping systems. Maximum seed weight plant^{-1} (3.20 g) was obtained by C_7 (sunflower + groundnut at 2:1 row ratio) which was statistically at par with C_1 (sole sunflower) and C_8 (sunflower + black gram at 3:1 row ratio). Cropping systems significantly influenced 1000 seed weight of sunflower. The maximum value of 1000 seed weight (39.23 g) was obtained by treatment C_8 (sunflower + black gram at 3:1 row ratio) which was statistically at par with all other cropping systems except C_4 (sunflower + black gram at 1:1 row ratio) and C_5 (sunflower + groundnut at 1:1 row ratio). The lowest value (27.26 g) was obtained by C_5 (sunflower + groundnut at 1:1 row ratio). Cropping systems significantly influenced the seed yield (kg ha^{-1}) of sunflower. During the periods of experimentation, sole sunflower gave higher seed yield than intercropped one which was mostly resulted from higher number of plant population in the sole stand than intercropping as it was replacement series of intercropping. The highest seed yield of sole sunflower *i.e.* C_1 was 1833.0 kg ha^{-1} while sunflower intercropped with black gram at 1:1 row ratio *i.e.* C_6 was 1495.7 kg ha^{-1}. Treatment C_6 (sunflower intercropped with black gram at 1:1 row ratio) was statistically at par with C_5 (sunflower + groundnut at 1:1 row ratio). The percentage increase of C_1 (sole sunflower) over C_6 (sunflower + blackgram in 2:1 ratio) and C_5 (sunflower + groundnut at 1:1 ratio) were 22.55% and 24.89%, respectively. The lowest seed yield (940.2 kg ha^{-1}) was obtained by C_7 (sunflower intercropped with groundnut at 2:1 row ratio).

Higher seed yield of sole sunflower than intercropped one was might be due to the row arrangements under replacement series of intercropping systems in the latter. During the periods of experimentation, sole sunflower gave higher seed yield than intercropped one which was mostly resulted from higher number of plant population in the sole stand than intercropping. The highest seed yield of (sole sunflower) C_1 was 1833.0 kg ha^{-1} while (sunflower intercropped with black gram at 1:1 row ratio) C_6 was 1495.7 kg ha^{-1}. Treatment C_6 (sunflower intercropped with black gram at 1:1 row ratio) was statistically at par with C_5 (sunflower + groundnut at 1:1 row ratio). The percentage increase of C_1 (sole sunflower) over C_6 (sunflower + blackgram in 2:1 ratio) and C_5 (sunflower+ groundnut at 1:1 ratio) were 22.55% and 24.89%, respectively. The maximum biological yield (4638.3 kg ha^{-1}) was obtained by (sole sunflower) C_1 which had differed significantly with all other cropping systems. While sunflower intercropped with groundnut at 2:1 row ratio, i.e., C_7 recorded lowest biological yield (3460.0 kg ha^{-1}) of sunflower. Oil content (%) and oil yield of

Table 2: Economics of sunflower as influenced by intercropping systems

Treatments	Cost of production (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	Benefit: cost ratio
C_1 – *Sole sunflower*	37865	73320	35455	0.93
C_2 – *Sole black gram*	36170	51354	15184	0.42
C_3 – *Sole groundnut*	40370	71579.2	31209.2	0.77
C_4 – *sunflower + black gram at 1:1 row ratio*	37517.5	77294	39776.5	1.06
C_5 – *sunflower + groundnut at 1:1 row ratio*	39432.5	90906.1	51473.6	1.30
C_6 – *sunflower + black gram at 2:1 row ratio*	37965.6	73958	35992.4	0.95
C_7 – *sunflower + ground nut at 2:1 row ratio*	39364	54790.9	15426.9	0.39
C_8 – *sunflower + black gram at 3:1 row ratio*	38182	49596	11414	0.30
C_9 – *sunflower + ground nut at 3:1 row ratio*	39232	61942.2	22710.2	0.58

Table 3: Competition functions of sunflower-based intercropping system

Treatments	Land Equivalent Ratio (LER)	Monetary Advantage (MA)	Aggressivity (A)	
			Sunflower	Legume
C_4 – sunflower + black gram at 1:1 row	1.20	13259.98	0.37	-0.37
C_5 – sunflower + groundnut at 1:1 row	1.25	18214.49	0.71	-0.71
C_6 – sunflower + black gram at 2:1 row	1.09	6175.99	0.68	-0.68
C_7 – sunflower + groundnut at 2:1 row	0.92	-4309.39	0.25	-0.25
C_8 – sunflower + black gram at 3:1 row	0.90	-5054.4	-0.01	0.01
C_9 – sunflower + groundnut at 3:1 row	0.85	-10969.8	0.28	-0.28

sunflower was significantly influenced by cropping systems during the period of experimentation (Table 1). Among the cropping systems, (sunflower intercropped with black gram at 2:1 row ratio) C_6 got highest oil content (40.40%). In terms of oil yield treatment C_1 (sole sunflower) obtained maximum oil yield (660.70 kg ha^{-1}) which was statistically at par with C_6 (sunflower intercropped with black gram at 2:1 row ratio). The percentage increase on oil yield of C_1 (sole sunflower) over C_6 (sunflower + blackgram in 2:1 ratio) was 9.45%. The lowest oil yield (340.35 kg ha^{-1}) was recorded by C_8 (sunflower + black gram at 3:1 row ratio).

Economics

The maximum cost of production (₹ 39432.5 ha^{-1}) was recorded by C_5 (sunflower + groundnut at 1:1 row ratio) followed by C_7, that is sunflower + ground nut at 2:1 row ratio (₹ 39364 ha^{-1}). The sailing price of sunflower seed, black gram seed and groundnut kernel were ₹ 40, ₹ 60 and ₹ 70 Kg^{-1}, respectively. Highest gross return of (₹ 90906.1 ha^{-1}) was recorded by sunflower + groundnut at 1:1 row ratio (C_5) followed by sunflower + black gram at 1:1 row ratio (C_4) which recorded the gross return of ₹ 77294 ha^{-1}. The lowest gross return (₹ 49596 ha^{-1}) was recorded by sunflower + black gram at 3:1 row ratio (C_8). The maximum net return of (₹ 51473.6 ha^{-1}) was recorded by the intercropping system sunflower + groundnut at 1:1 row ratio (C_5) whereas the lowest net return (₹ 11414 ha^{-1}) was recorded by (sunflower + black gram at 3:1 row ratio, that is, C_8. In terms of benefit: cost ratio, the highest value (1.30) was recorded by sunflower + groundnut at 1:1 row ratio (C_5) and the lowest benefit: cost ratio (0.30) was recorded by sunflower + black gram at 3:1 row ratio (C_8) (Table 2).

Competition Functions

Different competition functions, namely, land equivalent ratio (LER), monetary advantage (MA) and aggressivity are calculated to evaluate the efficiency of intercropping system. LER is a measure of relative advantage of intercropping over mono-cropping at a given degree of management. The LER values of sunflower + groundnut at 1:1 row ratio *i.e.* C_5, sunflower+ black gram at 1:1 row ratio i.e. C_4 and sunflower + black gram at 3:1 row ratio

i.e. C_6 were found to be above unity, which clearly indicated yield advantages *i.e.* there was yield advantages of mixed crops over sole crops (Table 3). It was observed that the maximum LER value (1.25) was obtained under sunflower + groundnut at 1:1 row ratio *i.e.* C_5 and the lowest LER (0.85) was obtained under sunflower + groundnut at 3:1 row ratio *i.e.* C_9. The results were in conformity with the findings of Rao *et al*. (2009). The highest monetary advantages of ₹ 18,214.49 and ₹ 13,259.98 were recorded by sunflower + groundnut at 1:1 row ratio *i.e.* C_5 and sunflower + black gram at 1:1 row ratio i.e. C_4, respectively gives an indication of economic advantages in intercropping over sole cropping. While treatment C_7 *i.e.* sunflower + groundnut at 2:1 row ratio, C_8 *i.e.* sunflower + black gram at 3:1 row ratio and C_9 *i.e.* sunflower + groundnut at 3:1 row ratio gave negative value, indicating that the treatments are not economically viable. Aggressivity gives simple measurement of how much the relative yield increase in species '*a*' is greater than for species '*b*'. The results showed that aggressivity of sunflower was positive with all intercropping treatments except C_8 (sunflower + blackgram in 3:1 ratio). The positive value of aggressivity indicated sunflower (except C_8) as dominant crop and legumes as dominated crops (except C_8). Greater value of aggressivity indicates higher mangnitude of competition. In the study, C_5 and C_6 exhibited greater aggressivity and C_4, C_7 and C_9 resulted in moderate level of aggressivity (Table 3).

CONCLUSION

From present investigation it may be concluded that intercropping of sunflower and groundnut with 1:1 ratio may be adopted in south Odisha conditions to obtain higher yield, monetary advantage, net return and benefit: cost ratio.

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