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Effect of variety, levels of fertilizer and bio-fertilizer on quality, microbial count and economics of cumin (*Cuminum cyminum* L.)

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Abstract
A field experiment was conducted during *rabi*, 2017-18 on loamy sand soil at Agronomy Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar to evaluate the effect of variety, chemical fertilizer and bio-fertilizers on growth and yield of cumin. Twelve treatment combinations comprising of two varieties (GC 3 and GC 4), two levels of fertilizer (100% and 50% RDF) and three levels of biofertilizers (*Azotobacter* + PSB, *Azospirillum* + PSB and NPK consortium) were laid out in randomized block design (factorial) with four replications. Significantly higher volatile oil content, net return and B:C ratio were found when cumin variety GC 4 was fertilized with 100% RDF (40:15:00 NPK kg/ha) and inoculated with *Azospirillum* + PSB. Higher microbial status of soil was found significantly higher under variety GC 4, 50% RDF and seeds inoculated with *Azospirillum*+ PSB.

Keywords: Cumin, variety, fertilizer, bioferilizer, quality, microbial count, economics

1. Introduction
Seed spices are known as an integral part of Indian culture that's why India is known as home of spices. The seed spices are annual herbs, whose dried seeds are known as spices and widely used in culinary, confectionary, perfumery, cosmetics and pharmaceutical industries. Cumin is extensively cultivated in India. Cumin aldehyde or cuminol is 36.31 per cent in cumin which attributes the specific value-added aroma. It has carminative, stomatic, anti-diarrheal and dyspecial medicinal properties. Cumin occupies 47.0 per cent of total seed spices area but accounts for 35.7 per cent of total seed spices production in the country.

Among different factors known to augment crop production, identification of new genotype having wider adaptability and responsiveness to input are considered essential for exploiting higher yield potential. The identification of such high yielding adaptable varieties as per crop growing situation is considered to be first and foremost step for development of production technology. This study will help in replacing older variety with newer one. It is an established fact that potential of the genotype is realized to the fullest extent when it is grown under optimum environment. Plant nutrients play specific and important role in growth and development of a plant. Adequate mineral fertilization is considered to be one of the most important pre-requisites in this respect. Nitrogen plays a key role in the synthesis of chlorophyll and amino acids, which contributes to the building units of protein and thus growth of plant. It also helps in early establishment of leaf area capable of photosynthesis and increased root development to enable more efficient use of water. Next to nitrogen, phosphorus is of paramount importance in crops for increasing yield. Phosphorus, apart from its role in root development and nodule formation, plays an important role in energy transfer in the living cell by means of high phosphate energy bonds ATP and ADP (Havlin *et al*., 2003) [4]. Therefore, there is need to work out optimum combination of nitrogen and phosphorous for cumin.

In recent years the rise in price of chemical fertilizers, scarcity of organic manures and poor nutrient use efficiency has led to search some alternative source of nutrition. Biofertilizers facilitate economizing fertilizer nutrient use through utilizing BNF system, solubilising less mobile nutrients from fixed components and recycling of nutrients from crop residues. It is evidently clear that application of biofertilizers enhances the accumulation of soil enzymes, which is directly reflected on soil fertility index.

The proper use of biofertilizers to crop not only provides economic benefit to the farmers, but also helps to improve and to maintain soil fertility and sustainability in natural ecosystem.

2. Material and Methods

The present investigation was conducted during the *rabi* season in 2017-18 at Agronomy Instructional Farm of Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Dantiwada. It is situated in the North Gujarat Agro-climatic Zone. The soil of research farm was loamy sand in texture, poor in fertility and water holding capacity, having pH 7.61, EC 0.11 dS/m; low in organic carbon (0.31%) and available N (136.56 kg/ha) and medium in available P_2O_5 (43.41 kg/ha) and K_2O (253.02 kg/ha). The experiment comprising of two varieties (GC 3 and GC 4) along with two levels of fertilizer (100% RDF and 50% RDF) and three levels of biofertilizers (*Azotobacter* + PSB, *Azospirillum* + PSB and NPK consortium) were applied in 12 different combinations (Table 1). The treatments were evaluated und randomized block design (factorial) with four replications. Seeds of cumin variety GC 3 and GC 4 were developed by Main Seed Spices Research Station, Jagudan. N and P_2O_5 applied through urea and DAP, respectively. The seeds were inoculated with respective strains of *Azotobacter*, *Azospirillum*, PSB and NPK consortium @ 25 ml/kg seed according to the treatment procured from Department of Microbiology, Anand Agricultural University, Anand. The crop was raised as per standard recommended cultural practices. Cumin was sown on 8^{th} November with seed rate of 10 kg ha^{-1} at 30 cm line spacing by broadcasting and harvested in last week of February.

The data recorded during the course of investigation were subjected to statistical analysis as per method of analysis of variance (Panse and Sukhatme, 1978) [5].

Table 1: Treatment details

Varieties (V)
V_1 = GC 3
V_2 = GC 4
Levels of fertilizer (F):
F_1 = 100% RDF (40:15:0, $N:P_2O_5:K_2O$,kg/ha)
F_2 = 50% RDF (20:7.5:0, $N:P_2O_5:K_2O$,kg/ha)
Biofertilizers (B):
B_1 = *Azotobacter* + PSB
B_2 = *Azospirillum* + PSB
B_3 = NPK consortium

3. Results and Discussion

3.1 Effect of variety

Data presented in Tables indicated that different treatments had a significant influence on seed quality, microbial count and economics of cumin. The highest volatile oil content (4.82%) was obtained in Variety GC 4. It might be due to inherent capacity of a particular variety. These findings are in close agreement with those reported by Anonymous (1997) [1], Anonymous (2003) [2], Anonymous (2010) [3] and Tamboli (2016) [6] in fennel. Higher microbial activity was found in GC 4 variety. This might be due to more soil aeration and higher soil moisture found in cumin crop sowing with GC 4 variety over GC 3. Highest values of gross return (₹ 66266/ha), net return (₹ 39452/ha) and benefit cost ratio of 2.47 was realized under GC 4 variety (V_2).

3.2 Effect of levels of fertilizer

Levels of fertilizer failed to exert significant influence on volatile oil content of cumin. However, 100% RDF (F_1) gave numerically maximum volatile oil content (4.12%). Higher microbial activity was found in treatment B_2 (*Azospirillum* + PSB) than rest of the treatments. Highest values of gross return (₹ 64314/ha), net return (₹ 38968/ha) and benefit cost ratio of 2.54 was realized under 100% RDF.

3.3 Effect of levels of biofertilizer

Differences in results due to various biofertilizers was found non-significant. Higher volatile oil content was obtained under seed inoculation with *Azospirillum* + PSB (4.14%). Higher microbial activity was found in treatment B_2 (*Azospirillum* + PSB) than rest of the treatments. Highest values of gross return (₹ 65700/ha), net return (₹ 41572/ha) and benefit cost ratio of 2.72 was realized under *Azospirillum* + PSB inoculation.

3.4 Interaction effect

The data (Table 5) clearly indicated that the highest gross return (₹ 81140/ha), net return (₹ 52984/ha) and benefit cost ratio of 2.88 was realized under treatment combination $v_2f_1b_2$ followed by $v_2f_1b_1$, which earned gross return (₹ 70126/ha), net return (₹ 41970/ha) and benefit cost ratio of 2.49. The lowest gross return (₹ 47089/ha), net return (₹ 18963/ha) and benefit cost ratio of 1.67 was realized under $v_1f_1b_3$.

Table 2: Effect of varieties, levels of fertilizer and biofertilizers on volatile oil content of cumin

Treatments			Volatile oil content (%)
Varieties (V):			
V_1	:	GC 3	3.30
V_2	:	GC 4	4.82
S.Em. ±			0.07
C.D. at 5%			0.19
Levels of fertilizer (F):			
F_1	:	100% RDF (40:15:00, $N:P_2O_5:K_2O$, kg/ha)	4.12
F_2	:	50% RDF (20:7.5:00, $N:P_2O_5:K_2O$, kg/ha)	3.99
S.Em. ±			0.07
C.D. at 5%			NS
Biofertilizers (B):			
B_1	:	*Azotobacter*+ PSB	4.06
B_2	:	*Azospirillum*+ PSB	4.14
B_3	:	NPK consortium	3.97
S.Em. ±			0.08
C.D. at 5%			NS
Interaction:			
V × F			NS
V × B			NS
F × B			NS
V× F × B			NS
C.V. %			8.1

Table 3: Microbial population in soil before sowing and after harvest of cumin crop as influenced by different treatments

Treatments		Total bacterial count (cfu/g)	Total fungal count (cfu/g)
A.	**Initial (before sowing)**	1.85 x 10^6	2.51 x 10^3
B.	**After harvest**		
Varieties (V):			
V_1 :	GC 3	2.56 x 10^6	4.42 x 10^3
V_2 :	GC 4	2.68 x 10^6	4.73 x 10^3
Levels of fertilizer (F):			
F_1 :	100% RDF (40:15:00, $N:P_2O_5:K_2O$, kg/ha)	2.54 x 10^6	4.42 x 10^3
F_2 :	50% RDF (20:7.5:00, $N:P_2O_5:K_2O$, kg/ha)	2.70 x 10^6	4.74 x 10^3
Biofertilizers (B):			
B_1 :	*Azotobacter*+ PSB	2.71 x 10^6	4.66 x 10^3
B_2 :	*Azospirillum*+ PSB	2.85 x 10^6	4.95 x 10^3
B_3 :	NPK consortium	2.30 x 10^6	4.11 x 10^3

Table 4: Effect of varieties, levels of fertilizer and biofertilizers on economics of cumin

Treatments		Seed Yield (kg/ha)	Straw Yield (kg/ha)	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	BCR
Varieties (V):							
V_1:	GC 3	356	640	26814	54040	27226	2.02
V_2:	GC 4	437	716	26814	66266	39452	2.47
Levels of fertilizer (F):							
F_1:	100% RDF	424	714	25346	64314	38968	2.54
F_2:	50% RDF	370	643	24705	56143	31438	2.27
Biofertilizers (B):							
B_1:	*Azotobacter*+ PSB	395	657	24124	59907	35783	2.48
B_2:	*Azospirillum*+ PSB	433	750	24124	65700	41572	2.72
B_3:	NPK consortium	362	628	24094	54928	30834	2.28

Selling price of cumin (₹/kg): (i) Seed: 150; (ii) Straw: 1

Table 5: Economics of different treatment combinations

Treatment combinations	Seed Yield (kg/ha)	Straw Yield (kg/ha)	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ ha)	BCR
$v_1f_1b_1$	382	627	28156	57927	29771	2.06
$v_1f_1b_2$	451	813	28156	68463	40307	2.43
$v_1f_1b_3$	310	589	28126	47089	18963	1.67
$v_1f_2b_1$	328	620	27515	49820	22305	1.81
$v_1f_2b_2$	336	614	27515	51014	23499	1.85
$v_1f_2b_3$	330	579	27485	50079	22594	1.82
$v_2f_1b_1$	463	676	28156	70126	41970	2.49
$v_2f_1b_2$	535	890	28156	81140	52984	2.88
$v_2f_1b_3$	403	690	28126	61140	33014	2.17
$v_2f_2b_1$	406	707	27515	61607	34092	2.24
$v_2f_2b_2$	410	682	27515	62182	34667	2.26
$v_2f_2b_3$	407	655	27485	61705	34220	2.25

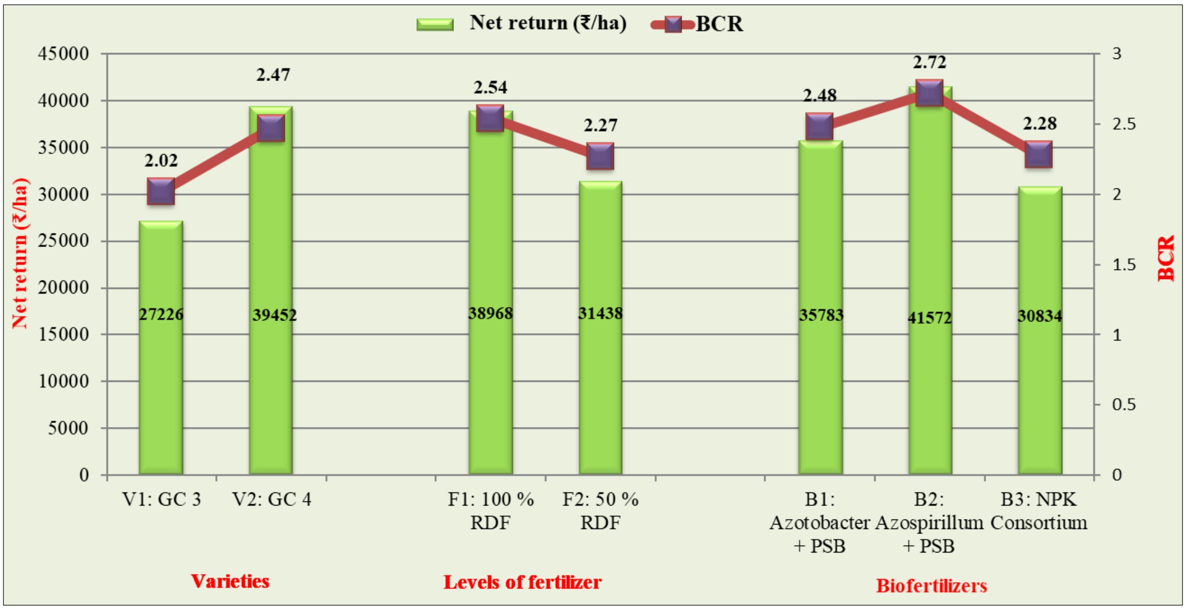

Fig 1: Effect of varieties, levels of fertilizer and biofertilizers on net return (₹/ha) and BCR

4. Conclusions
In the view of the results obtained from the present investigation, it can be concluded that for securing higher seed quality, microbial count and net return from cumin (*Cuminum cyminum* L.) raised on loamy sand soil, the cumin variety GC 4 should be fertilized with 100% RDF (i.e. 40:15:00 kg NPK/ha) along with seed inoculation with Azospirillum + PSB @ 25 ml/kg seed each.

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