Indian J. Agric. Res., 52 (3) 2018 : 284-289
Print ISSN:0367-8245 / Online ISSN:0976-058X

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
www.arccjournals.com/www.ijarjournal.com

Performance of bush type frenchbean varieties (*Phaseolus vulgaris* L.) with or without *rhizobium* inoculation

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Received: 16-01-2018 Accepted: 20-04-2018 DOI: 10.18805/IJARe.A-4981

ABSTRACT

An experiment was conducted during the *rabi* season of the years 2015-16 and 2016-17 at the Instructional Farm of Uttar BangaKrishiVishwavidyalaya, Pundibari, Cooch Behar to study the performance of eight bush type frnch bean (*Phaseolus vulgaris* L.) varieties (Shagun, Victoria, Falguni, Falkon Improved, Arka Komal, special Jhati Beans, Nandini and Basuki) regarding growth, fresh pod yield and quality in this region with and without *Rhizobium* inoculation. The experiment was laid out in factorial randomized block design with three replications. In case of inoculation treatment, irrespective of varietal differences, seeds were treated with *Rhizobiumphaseoli*10g/kg of seed. Common fertilizer dose of 80:40:40 $N:P_2O_5:K_2O$kg/ha was applied in each plot. The experimental results revealed that *Rhizobium* inoculation increased the yield and quality parameters *viz*, protein %, vitamin-A content and ascorbic acid content in the fresh pods of the frenchbean varieties. However, flowering and harvesting were recorded earlier in without *Rhizobium* inoculation treatment due to less accumulation of nitrogen content inside the plant bodies. Under *Rhizobium* inoculation Special Jhati Beans recorded the highest pod yield (23.05 tonnes/ha) followed by Victoria (22.43 tonnes/ha) and Arka Komal (21.95 tonnes/ha). Regarding without inoculation treatment ArkaKomal recorded the higher yield (20.05 tonnes/ha) followed by Special Jhhati Beans (20.01tonnes/ha) and Nandini (18.76 tonnes/ha).Considering the benefit: cost ratio, french bean varieties 'SpecialJhhati Beans' and 'Victoria' might be selected for the terai region of West Bengal with a benefit : cost ratio of 2.94 and 2.83 respectively.

Key words: French bean, *Rhizobium.*

INTRODUCTION

French bean (*Phaseolus vulgaris* L.) , the important leguminous vegetable is originated in warm temperate region of Central America (Mexico and Guatemala) and Southern America which is mainly grown for its tender green pod as well as dry beans (Rajmah).French beans are grown throughout the world and contribute nearly 30% of the total production of food legumes (Vasishtha and Srivastava, 2012). Majority of population in India are vegetarian and increased consumption of French bean as a pulse and vegetable can appropriately supplement their nutritional requirement (Singh *et al.*,2009) being rich source of nutrient and minerals *viz.*,protein content 17.5-28.7 % in dry seeds and 1.0-2.5 % in green pods, 3.2-5.0 % mineral matter, 4.2-6.3% crude fibre, 1.2-2.0 % crude fat and 340-450 Kcal energy (Sardana *et al.*,2000). In present days French bean is gaining popularity in the eastern and north eastern states of India as vegetable crops. Specifically its cultivation is becoming integral part of general cropping system in terai region of West Bengal due to having higher suitability during winter season. To meet the ever increasing demand of the crop achievement of higher yield of different varieties of french bean suitable for this region under favorable growing environment with proper evaluation is offoremost important for breeding. In addition, acclimatization of newly introduced established varieties in a particular region may result in higher yields as phenotypic expression is output of complex interaction between concerned genotypic materialsas well as the environmental components(Singh,2012). Beside the genotypic performances, *Rhizobium* treatment may influence the yield potentiality of the varieties due to formation of complex symbiotic relationship which make an important contribution to plant nutrition **(**Leikam *et al.,* 2007). *Rhizobia* bacteria interact with legume host plants to change atmospheric dinitrogen (N_2) gas into a form usable by the host plant and subsequent crops. This process is called symbiotic nitrogen fixation. The *Rhizobia* bacteria inhabit nodules on the roots of host legume plants. The host plant provides energy for the reactions through which the bacteria convert atmospheric dinitogen (N_2) gas into usable nitrogen (Leikam*et al.,* 2007).So, keeping all these information in purview present investigation was undertaken with the objectives of screening of the eight bush type frenchbean genotypes with respect to growth, yield and quality components as well as evaluate the effect of seed treatments with *Rhizobium* on growth, yield and quality of frenchbean.

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MATERIALS AND METHODS

Present investigation was conducted at the Instructional Farm of Uttar Banga KrishiViswavidyalaya, Pundibari, Cooch Behar (26°19' 86" N latitude and 890 23' 53"E longitude, at an elevation of 43 meter above the mean sea level), West Bengal, India during the winter seasons of 2015-16 and 2016-17. The soil of the experimental site is sandy loam in nature having a pH of 5.78 with 0.89% organic carbon,117.6 kg/ha available nitrogen,15.0 kg/ha available phosphorus and 104.23 kg/ha available potassium.This region comes under subtropical humid region with an average minimum temperature ranging from7to 8°C to and maximum of 24 to 33.2°C during the experimental period (Nov- March).

The experiment was laid out in randomized block design with three replications. Treatments consist of eight bush type frenchbean genotypes namely Shagun, Victoria, Falguni, Falkon Improved, Arka Komal, Special Jhati Bean, Nandini and Basuki with or without rhizobium inoculation. In case of Rhizobium inoculation seed was treated with *Rhizobium phaseoli*@ 10g/kg of seeds. Frenchbean seeds were sown in the field maintaining a spacing of 45 cm x15 cm with following of all standard package of practices. Sowing was done in middle of November of each year and harvesting was started from last week of February and was continued till March. Common fertilizer dose $N:P_2O_5:K_2O$ @ 80:40:40 kg/ha was applied. Data was recorded for growth, yield attributing parameters and yield that include plant height, number of primary branches per plant, flowering, first and last harvest of the concerned varieties, pod length, pod width, number of pods per plant, individual pod weight, yield per plant, total yield, nodule parameters like number of nodules per plant, dry weight of nodules per plant and three quality parameters include ascorbic acid content, Vitamin-Acontent and protein content of the fresh pods of frenchbean. Ascorbic acid content and beta carotene content of the fresh pods was determined by the method recommended by Ranganna (2001). Protein content of fresh pods of frenchbean was estimated by Lowry (1951) procedure.

The data obtained different parameters were subjected to statistical analysis by the Analysis of Variance method (Gomez and Gomez, 1984) and the significance of different sources of variations were tested by Error Mean Square by Fisher and Snedecor's 'F' test at probability level 0.05. For determination of critical difference at 5% level of significance, Fisher and Yates' table was consulted.

RESULTS AND DISCUSSION

Morphological characters: Average performance over two consecutive years recorded regarding morphological traits (Table 1) clearly indicated the significantly predominant effect of *Rhizobium* inoculation over the control irrespective of varieties for all the traits *viz.*, plant height (42.40 cm),

Table 1: Effect of Rhizobium inoculation on morphological characters of French bean varieties

	Plant height (cm)			Number of primary branches per plant			Number of nodules per plant			Dry weight of nodules per plant (mg)		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Rhizobiuminoculation												
Rhizobium	42.06	42.73	42.40	3.77	3.86	3.82	21.12	23.14	22.13	24.78	27.81	26.30
Control	40.33	40.82	40.58	3.62	3.39	3.51	11.43	12.22	11.83	10.34	12.49	11.42
CD (p=0.05)	1.26	1.23	0.84	N.S.	0.17	0.12	1.27	1.46	0.93	2.14	2.47	1.59
Variety												
Shagun	44.97	45.28	45.13	3.53	3.57	3.55	11.70	12.50	12.10	14.65	16.36	15.51
Victoria	41.46	41.54	41.50	3.70	3.63	3.67	20.10	21.60	20.85	18.46	20.52	19.49
Falguni	41.45	41.71	41.58	3.60	3.67	3.64	14.83	16.37	15.60	19.64	21.63	20.64
Falkon Improved	41.45	41.65	41.55	3.47	3.70	3.59	12.27	13.67	12.97	12.82	14.69	13.76
ArkaKomal	40.96	42.96	41.96	4.27	3.83	4.05	11.73	12.90	12.32	9.71	10.62	10.17
Special Jhhati Beans	40.44	41.16	40.80	3.50	3.37	3.44	10.47	12.73	11.60	9.56	12.37	10.97
Nandini	37.66	38.71	38.19	3.73	3.73	3.73	25.83	27.87	26.85	26.05	33.75	29.90
Basuki	41.18	41.46	41.32	3.73	3.50	3.62	23.27	23.82	23.55	29.60	31.28	30.44
CD (p=0.05)	2.51	2.46	1.69	0.37	NS	0.24	2.55	2.91	1.86	4.28	4.94	3.18

NS: Non significant

number of primary branches (3.82), number of nodule per plant (22.13) and dry weight of nodule per plant (26.30 mg).

However, among the different varieties, maximum plant height (45.13 cm) was recorded by Shagun and Arka Komal produced significantly higher number of primary branches i.e., 4.05. Present finding was supported by earlier research work of Anjanappa *et al.,* (2000). Considering the interaction effect, the highest plant height of 46.37 cm was obtained from Shagun when grown with *Rhizobium* inoculation treatment and Nandini recorded the lowest plant height (37.20 cm) when grown without *Rhizobium* inoculation treatment. Whereas, Arka Komal treated with inoculation was recorded for significantly highest numbers of primary branches i.e., 4.33.

Significantly highest number of nodules per plant was observed in Nandini (26.85) followed by Basuki (23.55) and Victoria (20.85); whereas, lowest number was observed in Special Jhhati Beans (11.60). Nodules dry weight per plant was highest in Basuki (30.44 mg) followed by Nandini (29.90) and lowest dry weight of nodules per plant was obtained from ArkaKomal (10.17 mg). With respect to interaction factors, the highest number of nodules per plant was observed in Nandini (33.50) followed by Basuki (29.27) and Victoria (26.34) when treated with *Rhizobium* inoculation. Similar kind of tendency was recorded for nodules dry weight per plant.

Flowering and fruiting attributes: Table 2 clearly indicated the significant positive effect of *Rhizobium* inoculation on earliness and fruiting span. *Rhizobium* inoculation was recorded with delayed flowering (53.02 days) in comparison to control that might be due to up-regulated vegetative growth as a result of more nitrogen accumulation inside the plant body. Nandini followed by Arka Komal were recorded to be earliest flowering i.e., 47.17 DAS and 47.58 DAS, respectively. As a result, earliest harvesting was started from Nandini (55.09DAS) followed by ArkaKomal (55.67 DAS). The differences in flowering duration in French bean varieties may be ascribed to genetic disparity as reported by Hussain (2005), Rana and Kumar (2008), Pandey *et al.*, (2011) and Prakash and Ram (2014). Interaction effect depicted the influence of *Rhizobium* inoculation on vegetative growth to promote delayed flowering i.e., earliest flowering was observed in Nandini (46.00 DAS) followed by ArkaKomal (46.17 DAS) when grown without *Rhizobium* inoculation and delayed flowering observed in Special Jhhati Beans (59.00 DAS) grown with *Rhizobium* inoculation treatment. As a result of delayed flowering, late harvesting, i.e, crop duration was also increased significantly in *Rhizobium* inoculation treatment (105.77 DAS) than without *Rhizobium* inoculation (100.54 DAS). Longest crop duration was obtained from Falguni (104.92 DAS) and shortest was in Basuki (100.67 DAS). Considering the interaction effects, harvesting was also earliest in Nandini (54.00 DAS) followed by ArkaKomal (54.34 DAS) when grown without *Rhizobium* inoculation treatment and the most delayed harvesting was obtained from Special Jhhati Beans (66.84 DAS) when grown with *Rhizobium* inoculation treatment as a result of delayed flowering.

Fruit characters, yield attributes and yield: The pooled analysis of two years data clearly revealed that (Table 3) *Rhizobium* inoculation has a little effect on podlength and width, but all the rest yield components affected significantly in positive direction. The increase in individual pod weight due to might be due to increased number of seeds per pod and 100 seed weight as referred by Yadegari and Rahamani (2010).Besides higher pod length (13.74 cm) and pod width

Table 2: Flowering and fruiting attributes of different varieties of French bean under *Rhizobium* inoculation and control.

Characters	Days to 50% flowering(DAS)			Days to first harvest(DAS)			Days to last harvest(DAS)		
Year	**2015-16**	**2016-17**	**Pooled**	**2015-16**	**2016-17**	**Pooled**	**2015-16**	**2016-17**	**Pooled**
					***Rhizobium* inoculation**				
I_1(with inoculation)	53.54	52.50	53.02	61.33	60.25	60.79	105.29	106.25	105.77
I_2(without inoculation)	50.79	50.04	50.42	58.67	57.75	58.21	99.83	101.25	100.54
SEm±	0.39	0.42	0.30	0.37	0.39	0.28	0.57	0.55	0.39
CD at 5%	1.13	1.21	0.84	1.08	1.15	0.79	1.64	1.61	1.12
					Variety				
V_1(Shagun)	55.17	53.00	54.09	63.00	60.83	61.92	102.50	103.50	103.00
V_2 (Victoria)	52.50	50.50	51.50	60.50	58.17	59.34	102.16	103.33	102.75
V_3(Falguni)	52.00	51.00	51.50	59.83	58.17	59.00	103.67	106.17	104.92
V_4(Falkon Improved)	54.67	53.33	54.00	62.17	61.00	61.59	103.83	104.83	104.33
V_5(ArkaKomal)	47.83	47.33	47.58	56.00	55.33	55.67	102.50	104.50	103.50
V_6(Special Jhhati Beans)	57.67	57.50	57.59	65.50	65.50	65.50	103.00	103.50	103.25
V_7(Nandini)	47.17	47.17	47.17	55.00	55.17	55.09	102.83	102.83	102.83
V_8(Basuki)	50.33	50.33	50.33	58.00	57.83	57.92	100.00	101.33	100.67
SEm±	0.78	0.83	0.59	0.74	0.79	0.56	1.13	1.11	0.79
CD at 5%	2.26	2.42	1.68	2.16	2.29	1.58	**N.S.**	**N.S.**	2.23

N.S. Non significant

Table 3: Fruit characters, yield attributes and yield of different varieties of French bean under *Rhizobium* inoculation and control.

Characters	Pod length (cm)			Pod width (cm)			Number of pods per plant			Individual fresh pod weight(g)			Yield/plant(g)			Total fresh yield (tonnes/ha)		
Year	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
***Rhizobium* inoculation**																		
I_1(with inoculation)	13.68	13.79	13.74	0.78	0.79	0.79	17.03	18.78	17.91	5.05	5.56	5.31	69.11	69.10	69.11	20.74	20.71	20.73
I_2(without inoculation)	17.68	13.49	13.62	13.56	0.73	0.75	0.74	15.32	16.89	16.12	4.43	4.83	4.63	63.32	64.22	63.77	17.37	17.99
SEm±	0.07	0.06	0.05	0.006	0.011	0.007	0.32	0.28	0.21	0.20	0.14	0.12	0.39	0.36	0.26	0.23	0.25	0.17
CD at 5%	N.S.	0.17	0.13	0.018	0.033	0.019	0.94	0.79	0.60	0.58	0.41	0.34	1.13	1.03	0.74	0.67	0.73	0.49
Variety																		
V_1(Shagun)	13.88	14.01	13.95	0.68	0.69	0.69	13.27	16.83	15.05	4.15	4.96	4.56	61.80	62.50	62.15	18.26	18.67	18.47
V_2 (Victoria)	12.67	12.89	12.78	0.75	0.75	0.75	18.37	19.00	18.69	4.50	5.01	4.76	71.51	73.85	72.68	20.51	20.65	20.58
V_3(Falguni)	13.49	13.57	13.53	0.63	0.64	0.64	12.30	13.37	12.84	3.68	3.90	3.79	44.61	44.71	44.66	15.47	15.87	15.67
V_4(Falkon Improved)	13.33	13.49	13.41	0.68	0.69	0.69	12.67	14.43	13.55	4.20	4.87	4.54	52.96	52.94	52.95	16.24	16.87	16.56
V_5(ArkaKomal)	14.20	14.29	14.25	1.25	1.28	1.27	15.47	16.03	15.75	6.55	7.03	6.79	77.52	78.52	78.02	20.69	21.32	21.01
V_6(Special JhhatiBeans)	13.37	13.50	13.44	0.71	0.71	0.71	22.63	25.88	24.26	5.38	5.24	5.31	83.14	84.26	83.70	21.37	21.69	21.53
V_7(Nandini)	14.03	14.11	14.07	0.66	0.68	0.67	20.20	20.43	20.32	4.97	5.22	5.10	74.00	73.72	73.86	20.31	19.99	20.15
V_8(Basuki)	13.70	13.76	13.73	0.69	0.69	0.69	14.50	17.67	16.09	4.49	5.35	4.92	64.18	62.80	63.49	19.61	19.76	19.69
SEm±	0.14	0.12	0.09	0.013	0.023	0.013	0.65	0.55	0.14	0.40	0.29	0.24	0.78	0.71	0.52	0.46	0.50	0.34
CD at 5%	0.39	0.34	0.26	0.036	0.066	0.037	1.88	1.59	0.40	1.12	0.83	0.68	2.26	2.06	1.47	1.34	1.46	0.97

(0.79 cm) higher values of individual pod weight (5.31 g), pods per plant (17.91), yield per plant (69.11g) and total fresh yield (20.73 tonnes/ha) was obtained from *Rhizobium* inoculation treatment than without inoculation treatment. However, significantly the longest pod length (14.25 cm), wider pod width (1.27 cm) and highest individual pod weight (6.79 g) was recorded by Arka Komal, whereas shortest pod length (12.78 cm) was observed in Victoria and smallest pod width (0.64 cm) and lowest individual pod weight (3.79 g) were noticed in Falguni. The variation in pod length, pod width and individual pod weight of French bean varieties observed in the present study may be due to their inherited traits and to some extent by environmental factors. Similarly, variability for pod length and pod width in different varieties of French bean was also reported by Kumar *et al.*,(2014) and Das *et al.*, (2014).Variation in number of pods per plant in different varieties was reported by Ramana *et al*., (2010) in frenchbean and Sharma *et al*., (2014) in pea.The highest yield per plant (83.70 g) and total fresh pod yield (21.53 tonnes/ha) were obtained from Special Jhhati Beans followed by Arka Komal having yield per plant of 78.02 g and yield of 21.03 tonnes/ha. Nandini (73.86 g) and Victoria (72.86 g) are statistically *at par* with respect to yield per plant and lowest pod yield per plant was recorded in Falguni (44.66 g). The results are also consensus with the findings of Das *et al.,* (2014) in French bean with different varieties. The variation in yield might be due to significant genotypic x environmental interactions as reported by Devi *et al.*,(2015).Considering the interaction effects, Arka Komal produced the longest pod length (14.36 cm) biggest pod width (1.27 cm) and highest individual pod weight (6.86 g) when grown with *Rhizobium* inoculation, whereas, shortest pod length (12.61 cm) was observed in Victoria and smallest pod width (0.61 cm) and lowest individual pod weight (3.61 g) were noticed in Falguni when grown without *Rhizobium* inoculation treatment. Higher number of pods per plant was obtained from Special Jhhati Beans (24.26) followed by Nandini (20.32), Victoria (18.69) and was lowest in Falguni (12.84).The findings of genotypic variation in number of pods per plant is also supported by Das *et al.,* (2014) and Yadav *et al.,* (2015) for different varieties in another experiment. The highest yield per plant (85.97 g) and total fresh pod yield (23.05 tonnes/ha) were obtained from Special Jhhati Beans when grown with *Rhizobium* inoculation treatment, whereas lowest yield per plant (41.84 g) and total fresh pod yield (13.77 tonnes/ha) in Falguni were recorded when grown without *Rhizobium* inoculation treatment.

Quality parameters: Data represented in Table 4 indicated that quality parameters likeβ-carotene content (IU), ascorbic acid content (mg/100g) and protein content (%) of the fresh French bean pods showed significant variation in different genotypes as well as *Rhizobium* inoculation treatment. Up regulation of bio-synthetic pathway on *Rhizobium* inoculation was noted for Vitamin-A (612.96 IU), ascorbic

Table 4: Quality parameters of different varieties of French bean under *Rhizobium* inoculation and control.

Characters	Vitamin-A content in fresh pods (IU)			Ascorbic acid content in fresh pods (mg/100g)			Protein content in fresh pods (%)		
Year	**2015-16**	**2016-17**	**Pooled**	**2015-16**	**2016-17**	**Pooled**	**2015-16**	**2016-17**	**Pooled**
***Rhizobium* inoculation**									
I_1(with inoculation)	612.70	613.22	612.96	15.32	15.54	15.43	2.07	2.10	2.09
I_2(without inoculation)	603.02	603.61	603.32	13.66	13.84	13.75	1.43	1.45	1.44
SEm±	0.54	0.46	0.36	0.094	0.11	0.073	0.013	0.011	0.008
CD at 5%	1.58	1.34	1.00	0.27	0.31	0.21	0.038	0.032	0.024
Variety									
V_1(Shagun)	596.14	596.96	596.55	18.77	18.95	18.86	1.51	1.53	1.52
V_2 (Victoria)	608.04	609.06	608.55	16.93	17.10	17.02	1.61	1.70	1.66
V_3(Falguni)	605.60	605.88	605.74	15.65	15.89	15.77	2.27	2.28	2.28
V_4(Falkon Improved)	618.39	618.57	618.48	14.68	14.79	14.74	2.04	2.04	2.04
V_5(ArkaKomal)	604.24	604.71	604.48	14.88	15.14	15.01	1.45	1.46	1.46
V_6(Special Jhhati Beans)	599.73	599.99	599.86	10.82	10.95	10.89	1.77	1.83	1.80
V_7(Nandini)	617.83	618.51	618.17	14.22	14.42	14.32	1.78	1.80	1.79
V_8(Basuki)	612.91	613.62	613.27	9.99	10.25	10.12	1.53	1.56	1.55
SEm±	1.09	0.92	0.71	0.19	0.21	0.15	0.026	0.022	0.017
CD at 5%	3.15	2.68	2.01	0.55	0.61	0.41	0.076	0.063	0.048

N.S. Non significant

acid content (15.43 mg/100g fresh pod) and protein content (2.09%). Although, enhancement of protein content in fresh pods compared to without inoculation (1.44%) ascribed due to higher nitrogen accumulation inside the plant body as supported by Khafa (2013).With respect to different varieties, Vitamin- A content in fresh pods was highest in Falkon Improved (618.48 IU) followed by Nandini (618.17 IU). The highest ascorbic acid content (18.86 mg/100g fresh pod) was obtained from Shagun followed by Victoria (17.02 mg/100g fresh pod) and Falguni (15.77 mg/100g fresh pod) and lowest amount of ascorbic acid content was recorded in Basuki (10.12 mg/100g fresh pod). These findings were supported by earlier research (Rashid, 2014). Significantly, the highest amount of protein content was estimated in Falguni (2.28%) followed by Falkon Improved (2.04%) and Special Jhhati Beans (1.80%) and was lowest in Arka Komal (1.46%).The results were corroborated with the findings of Yadav(2015) in frenchbean and Kalyani (2012) in cluster bean. The results of the interaction effects revealed that, the highest vitamin- content was recorded in Falkon Improved (623.15 IU) followed by Nandini (622.26 IU) with *Rhizobium* inoculation. The highest ascorbic acid content was recorded in Shagun (20.01 mg/100g fresh pod) and significantly highest amount of protein content was estimated in Falguni (3.09%). In all the cases interaction effect for non-inoculated treatments were resulted lower than the inoculated one.

CONCLUSION

From the present study, it may be concluded that *Rhizobium* inoculation increase the growth and yield parameters of the French bean and ultimately increase yield of French bean. Among the bush type French bean varieties, maximum fresh pod yield was recorded in Special Jhhati Beans (21.53tonnes/ha) which is also statistically *at par* with Arka Komal (21.01 tonnes/ha). More than 20tonnes/ha yield was recorded in Victoria (20.58tonnes/ha) and Nandini (20.15tonnes/ha). Considering the benefit: cost ratio, French bean varieties SpecialJhhati Beans and Victoria might be selected for the terai region of West Bengal.

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