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Ground reality assessment and possible strategies in improvement of red gram (*Cajanus cajan* (L.) Millsp.) in old alluvial plains of West Bengal

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Abstract

Average yield of pulse crops in the world during triennium ending 2014 was 890 kg ha^{-1} where as in the same period, India produced only 648 kg ha^{-1}, showing a yield gap by 27 per cent. The country has to import a large quantity of pulses every year to cater to the need of its domestic demand. Red gram is one of the 14 leguminous pulse crops that are reportedly grown in the country and it contributes about 15 percent of the national area as well as production under pulse crops. A farmer's plot experiment oriented study was conducted in a region comprised of all the seven blocks of the Jangipur Sub-division in Murshidabad district of West Bengal during the period from 2011-12 to 2014-15 in kharif season every year. Our experiment had two objectives, first one was to study performance of suitable cultivar along with better nutrient management practices for this zone, and second one was to study the yield gap for this crop grown with 3 varieties in the area, and the pictures of price cum profit status of the growers under purely rain fed old alluvial and laterite soil condition. Field experiment revealed that more grain yield was registered with the cultivar P 855 (2.35 t ha^{-1}) and significantly better than rest of the treated cultivars. This gave 37.42 % more yield over local farmer variety. With various integrated nutrient management practices, more grain yield was recorded with the 75 % RDF + 5 t FYM ha^{-1}, and was at par with the all treatment except 50 % RDF + 10 t FYM ha^{-1}. Production efficiency was more registered with the P 855, and was at par with all other treatments except local farmer cultivars. With subplot dealing of production efficiency, considerably more was create with 75 % RDF + 5 t FYM ha^{-1}, and was at par with all the treatment except 50 % RDF + 10 t FYM ha^{-1}. As per economics were concerned more of B:C ratio was found with the cultivar P 855 (2.18) with 75 % RDF + 5 t FYM ha^{-1} (1.89). Further with the second objective, the yield gap was found to range from 34 to 48 %. The farmers faced large discrepancies in the market regarding the sale of their surplus produce and ultimately they failed to enjoy high profits from growing this crop. But the crop is a promising one in the area provided strategic measures are taken for improvement.

Keywords: Red gram, rain fed, old alluvial soil, farmer's field

Red gram (differently named as Pigeon pea, Arhar, Congopea, Fio-fio, Noeyepea, Kadios, and Tur) is the second most important pulse crop in India after Bengal gram. It is one of the 14 pulse crops that are reportedly grown in the country and contributes about 15 per cent of the national area as well as production under pulse crops. Growing of this crop greatly enhance soil productivity. Growing of pulse not only helps to improve the soil fertility, but it also enhances soil productivity with improved microbial action in soil ecosystem (Mukherjee, 2015). Our various efforts since 1950-51 directed towards overall improvement in pulse crops scenario have made it possible to increase the production level only by about 180 percent as compared to over 460 percent in cereal crops as of now. As a result, we depend on import of pulses from other countries in order to meet the demand of requirements for a nation of over 1.2 billion population (Table 1). Integrated approach of nutrient management play significant role in pulse production (Mukherjee, 2015a). Average yield of pulse crops in the world during triennium ending 2014 was 890 kgha^{-1} where as in the same period; India produced only 648 kgha^{-1}, showing a yield gap of 242 kg or 27 per cent. This might be due to various problems related to improve nutrient management and crop husbandry practices. Weed management play crucial role in field crop production and it reduce crop yield approximate 34 to 63 % (Singh *et al*. 2004; Mukherjee, 2014)).This might be leads to more import of food grain in India.

Table 1: Import and export scenario of pulses in India (Quantity in '000 MT).

Year	Import		Export	
	Total pulse	**Red gram**	**Total pulse**	**Red gram**
2009-10	3509.57	389.33	99.92	0.27
2010-11	2698.66	346.14	208.03	0.03
2011-12	3364.80	470.94	174.21	0.66
2012-13	3839.30	506.39	201.71	1.56
2013-14*	2882.38	445.40	324.50	0.08

* April-February Source: DES (DAC) Report

Nutritionally, red gram in an important pulse crop used in various forms but mostly as split pulses or '*dal*'. The grains are rich in proteins, carbohydrate, fat and other nutritional factors (Table 2).

Table 2: Nutritional composition of red gram seed.

Sl. no.	Constituent	Status (%)
1.	Protein	19 to 23
2.	Starch	45 to 55
3.	Soluble sugars	3 to 5
4.	Fat	1 to 5
5.	Ash	3 to 4
6.	Lysine	1.2 to 1.4
7.	Methionine	0.1 to 0.3
8.	Cystine	0.3 to 0.5

Source: Hunsigi and Krishna (1998)

Red gram '*dal*' (split pulse seed) is also a rich source of other essential amino acids like tyrosine , tryptophan, phenylalanine, histidine, leucine and arginine, vitamins like thiamine(B_1), riboflavin(B_2), niacin(B_3), pantothenic acid(B_5), B_6 and folate(B_9) and elements like iron, calcium, magnesium, manganese, zinc etc. Red gram is hardy legume crop with deep root system. It has the ability to fix atmospheric nitrogen @ 31 to 97 kg ha^{-1} to the soil for succeeding crops. It also adds plant residue @ 20 to 25 qtl.ha^{-1} and produces sticks @ 50 to 60 qtl.ha^{-1} used as fuel wood. The leaves can be utilized to feed silkworms and plants are used to culture lac producing insect. It is obvious that we have to give more thrust on this crop in order to improve our pulse production scenario as well as reduce or minimise the bulk of pulses imported every year from other countries. West Bengal is one of the major pulse growing states in the country. Major districts in this state where red gram is produced are Murshidabad, Nadia, Bankura, Burdwan, West Midnapore and West Dinajpur. The study made with the following specific objectives mainly to see the influence of various cultivars and nutrient management practices on the performance of pigeon pear, yield gap with respect to red gram in a region of old alluvial soils in West Bengal and lastly to examine the price profit status of the farmers growing this legume and problems behind improvement of the crop with possible strategies.

Materials and methods

Murshidabad district lies between 23°43′30″N to 24° 50′ 20″N latitude and 87°49′17″E to 88°46′00″E longitude. The river Bhagirathi divides entire district into two parts. Western part having stiff clay soil, reddish in colour, developed from laterite rock, undulated topography, some what acidic in reaction is called 'Rarh' where as the eastern part contains alluvial and fertile soils, neutral to slight alkaline pH and this part is known as 'Bagri'. The district contains old alluvial, new alluvial and laterite soils. The climate of the district is hot, humid summer and mild cool winter. The maximum temperature reaches up to 42°C during summer and it may drop to a low of 7-9°C or even less during winter. However, length of winter is not certain in the recent years. Average annual rainfall is about 1350-1450 mm and about 75% of this is received during the monsoon period. The area under experimentation cum study was comprised of all the seven blocks of the Jangipur Sub-division. This was mostly with old alluvial and laterite soils. The soil was medium in organic carbon content (0.50-0.75%), available nitrogen, available potassium and available sulphur but low in available phosphorus content. Fixation of phosphorus is more because in acidic condition formation of insoluble phosphates of Fe and Al takes place. The pH was 5.5 to 6.5. Contact was made with the randomly selected farmers growing red gram in consecutive years with different varieties. Our study was confined from 2011-12 to 2014-15 to fulfil the two objective of the experiment. First objective include one field experiment, was conducted with the objective of study the suitability of cultivar with right dose of fertilizer in farmer field during the year. Four suitable cultivar of this region (viz. UPAS 120, P 855, P 9 and local cultivar) were observed in main plot treatment along with four subplot fertility levels treatments (viz. RDF, RDF + 5 t FYM ha^{-1}, 75 % RDF + 5 t FYM $ha^{-1}$and 50 % RDF + 10 t FYM ha^{-1}). Considering nutrient status of the soils in the zone, the recommended fertilizer dose (RDF) of 30 kg N ha^{-1}, 80 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1} was suggested for application. Nitrogen, phosphorus and potassium were applied in form of urea, single super phosphate and muriate of potash, respectively. Entire amount of all the fertilizers were applied as basal. Sowing of certified seeds treated 7 days before sowing with Carbandazime 50% WP @ 2.0 g per kg of seeds was done in the first year. Seed rate used was 12-15 kg ha^{-1}. Thinning at 12-15 DAS and weeding after 21 DAS were taken in practice. Other plant protection measures were taken as and when required. One additional experiment related to our second objective of the experiment, regarding yield performance and yield gap study in farmer field, following varieties were taken as follows (Table 3).

Table 3: Details of the varieties of red gram grown in study area.

Sl. no.	Name of variety	Duration (days)	Yield potential(kgha^{-1})	Number of selected grower farmer
1.	UPAS 120	150-160	1600-2000	6
2.	P9	130-140	1600-2000	4
3.	P855	140-150	2200-2500	3

Results and discussion

Amid different cultivars under main plot, utmost plant height, branches/plant was recorded with the P 855, and was significantly better to rest of the treatments (Table 4). With subplot treatment more height and branches/plant, was registered with the RDF + 5 t FYM ha^{-1} and was at par with the 75% RDF + 5 t FYM ha–1and full dose of suggested fertilizer application. Along with various cultivars under main plot, maximum LAI was recorded with the UPAS 120, and was better to rest of the treatments. However, main treatment effect failed to produce any noteworthy response on the above aspect. With subplot treatment more LAI was registered with the 75% RDF + 5 t FYM ha^{-1}, and was at par with the RDF + 5 t FYM ha^{-1} and full dose of recommended fertilizer application. Further observation on pods/plant and grain/pod revealed that, significantly higher of this parameter registered with the P 855, and significantly better to rest of the tested variety. With subplot treatment maximum pods/plant was found with the 75% RDF + 5 t FYM ha^{-1} and was at par with the all the treatment except 50% RDF + 10 t FYM ha^{-1}. Grain/pods, failed to produce any significant response with various subplot treatments, however more was registered with the 75% RDF + 5 t FYM ha^{-1}. Yield parameters were appreciably influenced by various treatments in field. Maximum grain yield was registered with the cultivar P 855 (2.35 t ha^{-1}) and significantly better to rest of the treated cultivars. This gave 37.42 % more yield over local farmer variety. With various integrated nutrient management practices, more of grain yield was recorded with the 75 % RDF + 5 t FYM ha^{-1} and was at par with the all treatment excetpt 50 % RDF + 10 t FYM ha^{-1}. Stalk yield was more observed with the P 855 and was at par with the UPAS 120 and P 9 cultivars, and notably superior to farmer chosen variety. With nutrient management practices, more stalk yield was recorded with the 75 % RDF + 5 t FYM ha^{-1} and significantly better to other set of experiment in subplot. The increase in plant height and yield indices under 75% RDF + 5 t FYM ha^{-1}, might be owing to adequate quantity of plant nutrient supplied to crop as per need during the growth period, resulting in favourable increase in growth and development of crop plant which leads towards an increase in plant height and yield indices. This corroborate with the finding of other researcher who reported that nutrient use efficiency enhanced with the integrated application in field (Mukherjee, 2013). Protein content in grain (%) failed to produce any significant response with various cultivars, however more was found with the cultivar P 855. With subplot treatment, radically more was found with RDF + 5 t FYM ha^{-1} and was at par with all the treatment apart from 50 % RDF + 10 t FYM ha^{-1}. Production efficiency was more registered with the P 855 and was at par with all other treatments except local farmer cultivars. With subplot dealing of production efficiency, considerably more was found with 75 % RDF + 5 t FYM ha^{-1}, and was at par with all the treatment except 50 % RDF + 10 t FYM ha^{-1}. As per economics were concerned more of B:C ratio was found with the cultivar P 855 (2.18) with 75 % RDF + 5 t FYM ha^{-1} (1.89).

Table 4: Plant height, yield indices and biological yield of pigeonpea as influenced by various treatments (Pooled mean of three years).

Treatment	Plant height	Braches/ plant	LAI	Pods/plant	Grains/ pod	Grain yield (t ha^{-1})	Stalk yield (tha^{-1})	Protein content in grain (%)	Production efficiency (kgha^{-1}day^{-1})	B: C ratio
					Cultivars					
UPAS 120	210.36	17.33	3.41	226.33	4.42	2.18	7.06	17.95	8.03	1.95
P 855	223.56	22.66	3.24	247.01	4.85	2.35	7.35	18.81	8.31	2.18
P 9	214.68	17.53	3.21	218.33	4.23	1.89	6.88	18.39	7.94	1.45
Local cultivar	201.11	17.11	3.07	220.36	4.31	1.71	6.32	17.89	7.25	1.85
SEm±	1.92	1.13	0.15	4.23	0.17	0.07	0.23	0.23	0.20	-
CD (*p*=0.05)	4.03	3.55	NS*	12.36	0.50	0.21	0.61	NS	0.52	-
					Futility levels					
RDF	223.94	20.13	3.35	235.02	4.63	1.98	7.98	18.24	8.03	1.69
RDF + 5 t FYM ha^{-1}	227.13	21.31	3.36	237.25	4.71	2.13	8.78	18.52	8.23	1.56
75 % RDF + 5 t FYMha^{-1}	222.36	22.32	3.52	240.23	4.85	2.19	9.32	18.13	8.79	1.89
50 % RDF + 10tFYMha^{-1}	206.9	14.56	3.01	211.00	4.51	1.45	5.68	17.89	6.52	1.63
SEm±	1.85	1.56	0.11	3.36	0.31	0.09	0.21	0.22	0.31	-
CD (*p*=0.05)	5.32	4.11	0.32	10.23	NS*	0.25		0.51	0.97	-
CV	17.36	11.23	7.36	12.36	13.65	16.31	14.23	9.87	8.69	

*Non significant

Yield performance and yield gap

Data on variety wise productivity for 3 years in form of average values are presented in Table 5. It has been found that newly introduced varieties were much better than the local variety which is being grown since long back traditionally. This was obvious because the high yielding new improved varieties are more responsive to applied nutrients and other agronomic treatments. The variety P 855 has been found to be the better performer than UPAS 120 and P 9 in all the years under study. However, large gaps are observed between the yield potential (Table 3) and the actual performance of the varieties in farmers' field. Yield gap over average potential yield was calculated as UPAS120 - 34 to 42%, P9 - 35 to 45%, and P855 - 44 to 48%.

In the year 2011-12, standing crop and seedling damage took place due to non availability of water and it was notified as draught by the district administration. During the year 2011-12, delayed monsoon and occurrence of draught like situation at the early stage of kharif cultivation resulted a huge loss in crop production. Availability and absorption of nutrients from the soil to the plants solely depend on availability of moisture in the soil. Limited rainfall during the peak kharif season (average 912.0 mm) in both the years was recorded. Being a hardy deep rooted crop, red gram saved the producers from total crop failure but this adverse behaviour of monsoon rains was one of the important reasons behind such yield differences. Loopholes in farmers' practices such as failure in timely sowing, delayed or no weed management and improper plant protection measures might be the other factors besides the contribution of the soils.

Table 5: Variety wise average yield of red gram in farmer's plot in kg ha^{-1}.

Year	Productivity (kg ha^{-1}) of different varieties			
	UPAS 120	P 9	P 855	Old local variety
2010-11	1190.3	1150.6	1250.0	678.3
2011-12	1030.5	980.9	1200.2	695.8
2012-13	1150.9	1170.8	1280.0	710.0
2013-14	1151.7	1171.3	1281.5	709.6

General observation reveals that lack of availability of quality seeds is perhaps the most important hindrance before the better yield improvement of this crop. It is also indicated from the very poor condition of the growers with local variety seeds traditionally stored by them year after year. At least 15-20% increase in production is possible only by the use of certified or quality seeds (Singh, 2013). Major thrust has to be given on how to reduce the productivity gap to the possible minimum level because vertical improvement is the most promising option in the red gram belt where majority of the farmers are with less than 1.0 acre of cultivable land. Some important specific strategies can be thought of for improvement of this crop.

1. Availability of seeds: Distribution or supply of certified or quality seeds by making involvement of the seed production and marketing agencies in order to improve the seed replacement ratio (SRR) from the poor present condition (below 15-18%). Government initiative for production of quality seeds in large scale in government owned seed and research farms for distribution among the growers at nominal price in well organised manner will certainly be a very good step in this context.
2. Rabi season cultivation: Adopting technology of growing red gram during post monsoon (Rabi) season besides practice in *kharif*.

A promising variety namely 'Rabi' (20/105), a variety from the state pulses and oilseeds research station (PORS), Berhampore, West Bengal can be taken. Sowing should be completed by 1st week of October with seed rate of 75 $kgha^{-1}$ for broadcasting. The variety is of 160-170 days duration. 'Sweta', 'Chuni' and 'Jagriti' are the other varieties that can also be taken. Long growing period with bright sun shine especially during flowering and seed setting available in rabi season are advantageous for better productivity. Water stagnation owing to heavy rains and flash flood from the upland and/or hilly areas of adjacent Jharkhand state that create a major problem in *kharif* season crop very often in certain portion of this belt can be avoided by practice of rabi cultivation of red gram in this area. Incidence of disease and insect pests is also low as compared to the *kharif* season crop. The crop can be easily harvested before sowing of jute or summer sesame in the cropping pattern. Moisture stored during monsoon rains even in the deeper layer of soil can be utilized efficiently.

3. Transplanting with polythene bag raised seedlings: Three to five weeks old seedlings raised in thin polythene bags packed with soil and well rotten organic manure can be transplanted on ridges or flat moist field by middle of August. This is very effective against loss in yield of pigeon pea due to poor plant population. Adequate number of healthy plants can be maintained through transplanting of polythene raised seedlings as a measure of contingency cropping. Plants grow vigorously under simulated upland conditions (ridges) thereby escaping both water stagnation and seedling blight. Transplanting with seedlings of 3 weeks age has been found significantly advantageous over transplanting of seedlings of more than 3 weeks age (Nadarajan, 2013). Polythene raised transplanted pigeon pea has potential to produce 30.0% higher yield over direct seeded crop grown in situ. Keeping the climatic uncertainties in recent years in mind, this technology developed in IIPR, Kanpur, India can be a very good option in this region of West Bengal. Delayed sowing, poor crop stand or crop damage due to heavy precipitation immediately after sowing or at seedling stage in the main field and consequent loss in yield can be successfully checked by this practice.

4. Farmers' training: Arrangement for periodic training to the farmers particularly the growers of red gram should be made so that the advances in the following practices are transmitted to them and ultimately the improvement in production is achieved.

(a) Soil test based nutrient cum soil management and application of biofertilizers mainly rhizobium culture specified for this crop according to cross inoculation grouping mixed with seed before sowing in order to facilitate biological nitrogen fixation (BNF).

(b) Proper seed treatment at 5-7 days before sowing and seed priming before sowing (for the purpose of hastening early and improved germination).

(c) Necessary plant protection measures in the field as well as for storage of produced seeds in farmer's room condition.

(d) Other agronomic practices such as land preparation, time of sowing, drainage management for the crop, sowing, weeding and other intercultural operations, water management, harvesting and processing, storing of seeds etc.

5. Adaptive researches should be undertaken keeping behaviour of local climate and soils in mind so that performance evaluation of varieties recommended for this zone, time of sowing, soil nutrient management, various plant protection measures etc. can be well assessed and modified or improved as per needs of the region. One state adaptive research farm (SARF) is situated in this zone that can be more strengthened with necessary infrastructure and utilized properly for this purpose.

Study on Price-profit status

Study made the authors experienced about an interesting fact that to convince the farmers to grow pigeon pea as a non traditional crop year after year was very much difficult unless they enjoy more profit than the crop(s) they are going with (Table 6 and Table 7). It has been observed that the picture of local market price as well as net benefit of the red gram cultivators was not in favour of the growers in the zone under study. Table 5 discloses the fact.

Table 6: Average market price scenario of red gram in the areas under study.

Year	Minimum support price (₹/ quintal)*	Rate of distress sale (₹/quintal)**	Retail price in local traders shop (₹./kg)***
2009-10	2300	900-1250	55-58
2010-11	3000	1400-1650	60-65
2011-12	3200	1600-1975	70-76
2012-13	3850	2000-2300	80-85
2013-14	-	2200-2400	90-100

*Declared by the Govt. of India. **Price at which the growers are compelled to sale the produce immediately after harvest. ***As 'Dal' or split pulse.

Table 7: Economics for cultivation of red gram in the area under study*.

A.	Costs particulars	Cost (₹)ha^{-1}
1.	Seeds, seed treatment etc.	775.00
2.	Land preparation	3450.00
3.	Fertilizers	4090.00
4.	Labour (for sowing, thinning, weeding, harvesting, processing etc.)	13600.00
5.	Misc.	500.00
	Total cost	22415.00
B.	Gross return (including sticks produced as fuel wood)	27898.00
C.	Net Return	5483.00

*Values are the mean of four years.

Though minimum support price is declared by the Government of India every year, farmer fails to get this benefit because he has no option open before him but to go for distress sale of his produce immediately after harvesting, threshing and sun drying to the middle order traders at a very low price. The crop is very much susceptible to store grain pests and the major insect pests are khapra beetle (*Trogoderma granarium*), rust-red flour beetle (*Tribolium castaneum*), gram dhora (*Callosobruchus chinensis*), lesser grain borer (*Rhypertha domonica*) and others. Lack of good storage facilities and poor socio-economic status of the growers are the most important factors behind this distress sale of freshly produced red gram seeds. However, when this product is entering the pulse mill via middle order traders or other agencies and returns to the local markets, it fetches very high retail price. Such type of discrepancies available in market certainly fails to encourage the farmers to grow this crop. More strengthened government initiative especially in regulation of market price as well as direct procurement from the farmers in government run procurement centres will obviously help to improve the picture as a whole. Data presented in the Table 7 indicates that net profit from the small piece of land on which the farmer grew red gram was not satisfactory at all as compared to other contemporary crop(s) information on which are not presented here. The small and marginal farmers are growing this crop year after year mainly for their own family consumption as well as production of some quantity of good quality fuel woods. Growing red gram on such low to medium fertile soils of old alluvial nature was very much encouraging in restoring the soil health of plots of farmers of low profile socio-economic status who generally do not think for adoption of application of organic manure and integrated nutrient management (INM) techniques.

It will be more fruitful corrective measure when our government will start playing the role that at present is being played by the middle man traders in the local market. Direct procurement at government declared price in fixed centres in the farmers' locality can encourage the growers to produce red gram. Presence of regulated market in sufficient number in good working condition with the required infrastructures is important in this regard. Regular monitoring and constructive evaluation of the on going system is must. It is to be always assured that the growers are enjoying the exact price for sale of their produce and exact sale proceeds. Arrangement for some sort of assistance or financial support to the growers can be thought of. The existing system of providing short term flexible agricultural loans through Kishan Credit Card or KCC account in the banks and other financial institutions are good. However, regular grass root level monitoring jointly by bank and government sides as well as updating the scale of finance on the basis of which loan amount is supposed to be fixed and its compulsory application should be taken care of. Various lacunae and hindrances present in this process of assistance should be obliterated so that the system becomes easy and less time consuming one. This is very important because many a time farmer fails to avail the loan well in ahead of starting the process of cultivation of the crop and once the sowing has been started or completed the bankers also show their unwillingness to provide him the financial support.

Conclusion

Integrated approach particularly with the specific strategies as mentioned in this paper is, right at the moment, of prime importance in order to bring the overall improvement regarding this crop. Considering the importance of red gram in particular and the pulses as a whole, it is perhaps the high time when we cannot neglect the need for betterment of the crop. The government, scientific community, the growers and all others related should come forward to provide the holistic efforts in the subject. It is better if we promote cultivar P 855 with integrated approach of fertilizer application i.e.75% RDF + 5 t FYM ha^{-1}, for better economic return.

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