

## Effect of Weed Management Practices on Weed Control, Yield and Economics of Soybean [Glycine max (L.) Merrill]

R. K. Raj<sup>1</sup>, K. K. Sinha<sup>1</sup>, Shalu Kumari<sup>2\*</sup>, Anup Kumar Choubey<sup>3</sup>, Ashok Pandit<sup>4</sup>  
and Dinesh Kumar Yadav<sup>1</sup>

<sup>1</sup>Department of Agronomy, RPCAU, Pusa, Samastipur, Bihar, India.

<sup>2</sup>Department of Agronomy, Institute of Agriculture, V.B.U, Santiniketan, West Bengal, India.

<sup>3</sup>K.V.K, Aurangabad, Bihar, India.

<sup>4</sup>R.R.S, Agwanpur, Saharsa, Bihar, India.

### Authors' contributions

This work was carried out in collaboration among all authors. Author RKR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author KKS help in conducting the experiment. Authors SK and AKC managed the analyses of the study. Authors AP and DKY managed the literature searches. All authors read and approved the final manuscript.

### Article Information

DOI: 10.9734/CJAST/2020/v39i930620

#### Editor(s):

(1) Dr. Sunil Kumar Mukherjee, International Centre for Genetic Engineering and Biotechnology, India.

#### Reviewers:

(1) Paul Kwaku Tandoh, Kwame Nkrumah University of Science and Technology, Ghana.

(2) Zvonko Pacanoski, Republic of Macedonia.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/56648>

Original Research Article

Received 27 February 2020

Accepted 04 May 2020

Published 13 May 2020

### ABSTRACT

The experiment was laid out Tirhut College of Agriculture, farm Dholi, Muzaffarpur, Bihar during *khari* season 2016, to study the effect of weed management practices on weed control, yield and economics of soybean [*Glycine max* (L.)]. Hand weeding twice at 25 and 45 DAS was found most effective to control weeds in soybean and recorded lowest weed count, weed dry matter and highest weed control efficiency. Among herbicide, application of Pendimethalin 1.0 kg/ha as PE (Pre-emergence) and Imazethapyr 55 g/ha as PoE (Post-emergence) at 25 DAS was found to be more efficient and cost effective to reduce weed population/m<sup>2</sup> (53.94 & 67.22), dry weight of weeds/m<sup>2</sup> (21.16 & 45.86 g) an increased weed control efficiency (53.86 & 68.83%) significantly in both the stages 30 and 60 DAS. Beside it, Pendimethalin 1.0 kg/ha + Imazethapyr 55 g/ha at 25 DAS,

\*Corresponding author: E-mail: shalukumari0017@gmail.com;

Pendimethalin 1.0 kg/ha + one hand weeding at 40 DAS and hand weeding twice at 25 and 45 DAS were equally efficient in increasing the grain yield, straw yield, weed index and gross returns than control but net returns (₹39870/ha) and benefit-cost ratio (1.70) was obtained maximum only with Pendmethalin 1.0 kg/ha and Imazethapyr 55 g/ha at 25 DAS.

*Keywords: Pendimethalin; imazethapyr; weed management; soybean.*

## 1. INTRODUCTION

Soybean serves the dual purpose for being grown both as an oilseed and pulse crop as well [1]. It has been termed as miracle bean because of higher protein (40%) and oil (20%) content [2]. It has very high potential among grain legume crops for combating acute malnutrition. The quality of soy protein is equivalent to that of animal protein and soybean is also a good source of dietary fibre, calcium, magnesium, phosphate, thiamine, riboflavin, niacin, etc. Soybean has also been reported to have medicinal properties in combating diabetes, cancer, heart disease, etc. Another significance of this crop is in its ability to fix atmospheric nitrogen. The productivity of soybean in India is only 857 kg/ha which is very low against a world average of 2293 kg/ha (FAO, 2006). One of the major reasons for lower productivity is abiotic and biotic factors encountered during crop season. Among the biotic factors, weed is most crucial and responsible for reduction in yield from 20-77 per cent depending on the type of soil, season and intensity of weed infestation [3,4]. Soybean are not strong competitors in the early part of the season, therefore weeds out grow them. Heavy infestation of weeds in soybean greatly interferes with timeliness and efficiency of harvest. Soybean usually develops a full canopy cover at eight weeks after emergence and can then compete with weeds up to maturity. Little or no reduction in yield occurs if soybean are kept weed free for the first four weeks. This is the critical period for weed competition in soybeans. The conventional method of weed control is time consuming, expensive and laborious. It is more favourable to use chemicals due to scarcity of human labour during peak season [5]. Herbicides alone or in combination with hand weeding have been found quite effective in controlling weeds and increasing the yield of soybean [6]. Beside it, herbicides provide effective weed control when field is not ready for mechanical/manual weeding due to rainfall. Therefore, now-a-days farmers are showing increasing interest in the use of herbicides for controlling weeds with the urge of reducing cost of cultivation owing to shortage of and high cost of labour [7]. The pre-emergence

herbicides are found to be effective in controlling the weeds during early stages but these failed to show the effective results on weed emergence at later stages of the crop. To overcome this problem, application of post-emergence herbicides are gaining popularity as it provides the farmers to opt the application time ranging from 10 to 30 days after sowing. Common post-emergence herbicides like imazethapyr are useful in controlling annual grass, broadleaf weeds and perennial sedges and quizalofop-p-ethyl is applied for selective control of perennial and annual grass weeds in peanut [8]. Pendimethalin inhibits both cell division and cell elongation in the roots and shoot meristems of the susceptible plants. It is applicable on the soil surface as pre-emergence spray and its active ingredient penetrated into the germinating weed seedlings (both monocot and dicot) through the hypocotyl. The seedlings died before or shortly after emergence. This herbicide acts almost exclusively through radical, and hence effective weed control in initial stage due to higher rate of killing of the juvenile weed seedling. Imazethapyr is a broad-spectrum imidazolinone herbicide, absorbed by the foliage and roots with rapid translocation in the xylem and phloem to the meristematic regions where it accumulates. It controls weeds by reducing the levels of three branched-chain aliphatic amino acids, isoleucine, leucine and valine, through the inhibition of acetolactate synthase, an enzyme common to the biosynthetic pathway for these amino acids. This inhibition causes a disruption in protein synthesis which, in turn, leads to an interference in DNA synthesis and cell growth. Imazethapyr applied as PPI, PRE and POE controls monocot and dicot weeds and had a strong residual life [9,10]. Jha and Soni [11] reported that maximum weed control efficiency (80%) with the application of pendimethalin @ 0.75 kg/ha followed by imazethapyr @ 0.75 kg/ha.

Keeping in view the aforesaid points present study was planned to study the effect of suitable weed management practices to control weeds in soybean with lower cost and higher grain yield.

## 2. MATERIALS AND METHODS

The field experiment was conducted during *khariif* season of 2016 at the research farm of Tirhut College of Agriculture, Dholi, Muzaffarpur which is situated on the southern bank of the river Burhi Gandak at an altitude of 52.18 meter above mean sea level and lies at 25°.98' N latitude and 85°.6' E longitude. The area has subtropical climate with hot and dry summer, moderate rainfall and cold winter. The total rainfall received during the crop season was 344.60 mm with good distribution. The maximum and minimum temperature during the crop-growth period ranged between 29.30°C to 34.50°C and 20.70°C to 27.00°C during 2016. The relative humidity recorded during the growth period of crop varied from 91.1 to 99.1%. The soil was sandy loam (52.78 % sand, 38.10 % silt and 10 % clay) in texture and moderately alkaline in reaction (pH 8.3) with electric conductivity 0.37 dS/m, low in organic carbon (0.41%), available N (204 kg/ha), available P<sub>2</sub>O<sub>5</sub> (17.55 kg/ha) and available K<sub>2</sub>O (108.62 kg/ha). The experiment was carried out in split-plot design having four weed management viz. Control, Hand weeding at 25 and 45 DAS, Pendimethalin 1.0 kg/ha (PE) + one hand weeding at 40 DAS and Pendimethalin 1.0 kg/ha (PE) + Imazethapyr 55 g/ha (PoE) at 25 DAS in sub-plot and replicated thrice. The soybean variety, JS-335 was sown on 03 July, 2016 in row 30 cm apart using seed rate of 75 kg/ha in a plot measuring 7.2 m<sup>2</sup>. Full dose of nutrient sources were applied as basal prior to sowing in band. Pendimethalin was applied next day of sowing and Imazethapyr was applied at 25 DAS. The spraying was done with flat fan nozzle. Hand weeding was done with the help of *khurpi* at 25 and 45 DAS as per treatment. The data on weed population and weed biomass were taken at 30 and 60 DAS with the help of random quadrat (0.25 m) method. Weed control efficiency and weed index was calculated by employing formula as given by Tripathi et al. [12]

$$W.C.E = \frac{DW_c - DW_t}{DW_c} \times 100$$

Where,

W.C.E= weed control efficiency, DW<sub>c</sub> = dry weight of weeds under weedy check, DW<sub>t</sub>= dry weight of weeds under weed control treatment

$$WI = \frac{X - Y}{X} \times 100$$

Where, WI= Weed index (%), X=Yield obtained from minimum weed competition plot, Y= Yield obtained from treated plot.

Seed yield was recorded in each plot after harvest. The economics of different treatments were computed by considering the prevailing market price of inputs and produce of soybean. The data were statistically analysed.

## 3. RESULTS AND DISCUSSION

### 3.1 Weed Control

Population of weeds increased with advancement of crop age up to 60 DAS under all the weed management practices. Different weed management practices were found highly effective in controlling the weeds at all the stages of crop growth. Hand weeding at 25 and 45 DAS recorded lowest population of weeds which may be due to complete removal of weed flora at 25 and 45 DAS by manual weeding. However, in control plots were recorded highest weed population among the treatments. Pre-emergence application of Pendimethalin brought about significant reduction of weeds in early stage (30 DAS). Moreover, the post-emergence herbicides were applied only 25 DAS and the time gap between application and expression of effect at the time of observation was limited. This may be the reason for less control of weeds by post-emergence herbicides at 30 DAS. Therefore, Pendimethalin 1.0 kg/ha + Imazethapyr 55 g/ha at 25 DAS and Pendimethalin 1.0 kg/ha + one hand weeding at 40 DAS were equally effective for controlling the weeds at 30 DAS. However, at 60 DAS the scenario was different than observed at 30 DAS. Pendimethalin as pre-emergence application followed by either of Imazethapyr or one hand weeding at 40 DAS significantly reduced weed population and weed biomass at 60 DAS in compare to weed-control.

No weeding system produces maximum weed dry weight at both stages of crop growth. This might be due to unchecked growth in this system, where the weeds continued to grow freely and enjoyed all the growth factors more efficiently, and as such accumulated higher dry matter. Under hand weeding system, as the weeds were removed at 25 and 45 DAS, weed dry weight decreased drastically but again tend to recoup towards maturity due to regeneration or commencement of new flushes. The weed dry weight (45.86 g/m<sup>2</sup>) slowly increased in the plot treated with Pendimethalin 1.0 kg/ha + Imazethapyr 55 g/ha at 25 DAS towards maturity of the crop because of decreasing trend of effectiveness resulting in regeneration of existing

weeds and emergence of new weed seedlings in the later stages of crop growth. That's why, With advancement in crop age i.e. at 60 DAS, hand weeding at 25 and 45 DAS (88.45 %) recorded significantly higher weed control efficiency than Pendimethalin 1.0 kg/ha + Imazethapyr 55 g/ha at 25 DAS (68.83 %) but was at par with Pendimethalin 1.0 kg/ha + one hand weeding at 40 DAS (87.28 %). Sylvestre et al. [13] also reported similar observation that Pendimethalin (0.75 kg/ha) at 30 DAS *fb* Imazethapyr (100 g/ha) at 20 DAS recorded minimum weed density and weed dry weight as compare to alone application of Pendimethalin.

Among the herbicides, Imazethapyr is known to be very effective in controlling broad range of weeds including annual broadleaved and some grasses in soybean and other legume crops [14]. More reduction in weed dry weight by reducing the weed density in these treatments might have resulted in higher weed control efficiency. The effective weed management, particularly within the first 40 to 45 days is more critical and later the crop canopy by and large keeps the weed count low in soybean.

Weed index refers to reduction in yield due to the presence of weeds in comparison to the yield of twice hand weeding at 25 and 45 DAS. Lower value of weed index was found in Pendimethalin 1.0 kg/ha + one hand weeding at 40 DAS (2.24) and Pendimethalin 1.0 kg/ha + Imazethapyr 55 g/ha at 25 DAS (4.97) and both of them were at par with each other due to equally effective for controlling weeds at the time of critical period of crop-weed competition.

### 3.2 Yield

Results showed that the effect of all weed management practices significantly influenced the yield of soybean over control (Table 2). Pendimethalin 1.0 kg/ha + Imazethapyr 55 g/ha at 25 DAS (15.86 kg/ha) was produced similar grain yield compare to Pendimethalin 1.0 kg/ha + one hand weeding at 40 DAS (16.26 kg/ha) and hand weeding at 25 and 45 DAS (16.71 kg/ha) while all of them significantly higher than control (8.79 kg/ha). This might be due to pre-emergence application of pendimethalin which prevented emergence of monocot and grassy weeds by inhibiting root and shoot growth, while imazethapyr was responsible for inhibition of acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS) in weeds which caused destruction of these weeds at 3-4 leaf stage [15]. Therefore, the crop was kept free of competition with weeds at the early critical stages of crop growth which resulted in favourable environment to have higher nutrient uptake and better source sink relationship. Vijay et al. [16] have also reported increase in seed yield under pendimethalin @ 2.5 l/ha followed by imazethapyr @ 75 g/ha at 20 DAS was due to its effectiveness in controlling weeds and improvement in growth and development of crop and higher yield attributes of soybean crop. The increase in yield under these treatments may be attributed to concomitant reduction in weed dry matter, which accounted for reduction in crop weed competition, and provided congenial environment to the crop for better reproductive potential. Treatments recording higher grain yield also recorded higher yield of straw in the weed

**Table 1. Effect of weed management practices on weed control of soybean**

Treatments	Weed population (No./m <sup>2</sup> )		Weed dry weight (g/m <sup>2</sup> )		Weed control efficiency (%)		Weed index
	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	
Weed management Control	105.80	140.12	45.74	146.84	0.00	0.00	48.12
Hand weeding at 25 and 45 DAS	14.13	23.80	4.24	16.98	90.72	88.45	0.00
Pendimethalin @ 1.0 kg/ha as PE + one hand weeding at 40 DAS	56.52	26.23	22.19	18.73	51.55	87.28	2.24
Pendimethalin @ 1.0 kg/ha as PE and imazethapyr @ 55 g/ha as PoE at 25 DAS	53.94	67.22	21.16	45.86	53.80	68.83	4.97
S.Em.±	1.58	2.02	0.37	1.09	1.43	1.81	1.95
C.D.( P=0.05)	4.60	5.86	1.06	3.17	4.16	5.25	5.67

**Table 2. Effect of weed management practices on yield and economics of soybean**

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)	Total cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C Ratio
Weed management Control	8.79	17.19	33.07	20659	35922	15263	0.73
Hand weeding at 25 and 45 DAS	16.71	28.11	37.27	30359	66932	36573	1.20
Pendimethalin @ 1.0 kg/ha as PE + one hand weeding at 40 DAS	16.26	27.65	36.86	27119	65190	38071	1.41
Pendimethalin @ 1.0 kg/ha as PE and Imazethapyr @ 55 g/ha as PoE at 25 DAS	15.86	26.93	36.84	23705	63576	39870	1.70
S.Em.±	0.37	0.64	0.02		1519.10	1519.10	0.05
C.D.( P=0.05)	1.10	1.86	NS		4408.69	4408.69	0.16

free environment. The reduction in straw yield due to weed infestation was obviously because of the reduced growth and development of vegetative attributes and reduced dry matter production by crop plants under intense weed competition in control condition.

The weed free environment recorded significantly higher harvest index than control condition. This was probably due to better water and nutrient availability resulting in enhanced sink capacity and higher grain productivity under hand weeding and Pendimethalin 1.0 kg/ha + one hand weeding at 40 DAS and Pendimethalin 1.0 kg/ha + Imazethapyr 55 g/ha at 25 DAS.

### 3.3 Economics

Maximum gross returns (₹ 66932/ha) was recorded under hand weeding at 25 and 45 DAS which was closely followed by Pendimethalin 1.0 kg/ha + one hand weeding at 40 DAS (₹ 65190/ha) and Pendimethalin 1.0 kg/ha and Imazethapyr 55 g/ha at 25 DAS (₹ 63576/ha) treated plots. These three were at par with each other. This might be due to the fact that higher weed control efficiency of these treatments produced higher seed and stover yield thus realizing higher gross returns. However, gross returns obtained under weed-control plot (₹ 35922/ha) was significantly lowest among the treatment as yield of both seed and stover was lowest in this treatment due to fact that weed infestation resulted into significant reduction of yield. Similar findings were reported by several authors [17,18]. Although hand weeding at 25 and 45 DAS recorded highest gross returns over all other treatments but it failed to realize highest net return and B: C ratio. It was found as reverse trend of gross returns. So, highest net return

(₹ 39870/ha) and B: C ratio (1.70) was recorded in application of Pendimethalin 1.0 kg/ha and Imazethapyr 55 g/ha at 25 DAS. This is accorded to higher cost of cultivation of soybean with hand weeding at 25 and 45 DAS involving more human labours and higher wages. This cost was reduced in the treatment Pendimethalin 1.0 kg/ha and Imazethapyr 55 g/ha at 25 DAS by using herbicides effectively manage weeds with minimizing human labours. Vijay et al. [16] have also conclude that sequential application of pendimethalin @ 2.5 l/ha followed by either imazethapyr @ 75 g/ha or imazethapyr + imazamox @ 100 g/ha at 20 DAS is effective and economical weed management practice in soybean. Control plot recorded lowest net returns (₹ 15263/ha) and B: C ratio (0.73). Besides, it is quite important to note that keeping the land free of weeds throughout the crop growth period is practically impossible by the farmers, since involves huge cost on labour.

### 3.4 Human Risk Involved

Pendimethalin is slightly toxic if ingested, inhaled or absorbed through the skin. The most probable occasion for human exposure is to applicators during mixing, loading, spraying and flagging [19]. Pendimethalin is a mild skin irritant [20]. Inhalation of dusts or fumes may be mildly to moderately irritating to the linings of the mouth, nose, throat and lungs [21]. Pendimethalin's herbicidal effects are related to inhibition of cell division and cell elongation. It is absorbed by plant roots and shoots. Pendimethalin is not absorbed by the leaves of grasses. Only very small amounts are taken up by plants from the soil. Once absorbed into plant tissues, translocation is limited and pendimethalin breaks down via oxidation. Residues on crops at harvest

are usually below detectable levels (0.05 ppm) [21]. Ingested pendimethalin is largely unabsorbed by the bloodstream and excreted through the feces. Pendimethalin which does become absorbed into the bloodstream from the gastrointestinal tract is rapidly metabolized in the kidneys and liver and is then excreted in the urine [22].

#### 4. CONCLUSION

Pendimethalin 1.0 kg/ha + Imazethapyr 55 g/ha at 25 DAS was equally effective for controlling the weeds and produced similar soybean yield to that of Pendimethalin 1.0 kg/ha + one hand weeding at 40 DAS and hand weeding twice. Therefore, it may be concluded that Pendimethalin 1.0 kg/ha + Imazethapyr 55 g/ha at 25 DAS could be used as cost effective weed management practices in soybean.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

#### REFERENCES

1. Thakare KG, Chore CN, Deotale RD, Kamble PS, Sujata BP, Shradha RL. Influence of nutrients and hormones on biochemical and yield and yield contributing parameters of soybean. *Journal of Soil and Crop*. 2006;16(1):210-216.
2. Chauhan GS, Joshi OP. Soybean [*Glycine max* (L.) Merrill]: 21<sup>st</sup> century crop. *Indian Journal of Agriculture Science*. 2005;75(8):461-469.
3. Billore SD, Joshi OP, Ramesh A. Energy productivity through herbicidal weed control in soybean. *Indian Journal of Agricultural Sciences*. 1999;69(11):770-772.
4. Kuruchania SP, Rathi GS, Bhalla S, Mathew R. Bio-efficacy of post emergence herbicides for weed control in soybean. *Indian Journal of Weed Science*. 2001;33(1&2):34-37.
5. Jain VK, Chauhan YS, Bhargava MK, Sharma AK. Chemical weed Control in soybean [*Glycine max* (L.) Merrill]. *Indian Journal of Agronomy*. 2000;45(1):153-157.
6. Kumar D, Chandrasekhar BL, Mishra PK. Effect of integrated weed management on economics of soybean [*Glycine max* (L.) Merrill] under vertisols of Chhattisgarh. *Annals of Agricultural Research*. 2003;24:212-214.
7. Savu RM, Choubey NK, Shrivastava GK, Tiwari N. Effect of chemical weed control on nitrogen uptake, weed weight and yield of groundnut under Chhattisgarh plains. *Environment and Ecology*. 2005;23(3):400-402.
8. Singh NK, Desai CK, Rathore BS, Chaudhari BG. Bio-efficacy of herbicides on performance of mustard, [*Brassica juncea* (L.)] and population dynamics of agriculturally important bacteria. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*. 2015;1-6.
9. Punia SS, Singh S, Yadav D. Bioefficacy of imazethapyr and chlorimuron-ethyl in cluster bean and their residual effect on succeeding rabi Crops. *Indian Journal of Weed Sciences*. 2011;43 (1&2):48-53.
10. Taylor FR, Carlson SJ, Arnold TL. Update on imazethapyr development and regulatory status. In: *Proceeding North Central Weed Control Conference*. 1988;43:42.
11. Jha AK, Soni M. Weed management by sowing methods and herbicides in soybean. *Indian Journal of Weed Science*. 2013;45(4):250-252.
12. Tripathi HC, Singh RS, Mishra VK. Effect of sulphur and zinc nutrition on yield and quality of chickpea (*Cicer arietinum* (L.)). *Indian Society of Soil Science*. 1971;45(1):123-126.
13. Sylvestre H, Murthy KNK, Shankaralingappa BC, Devendra R, Sanjay MT, Ramachandra C. Effect of pre and post-emergence herbicides on weed dynamics, growth and yield of soybean [*Glycine max* (L.) Merrill]. *Advances in Applied Science Research*. 2013;4(4):72-75.
14. Patel RK, Shobha S, Dwivedi AK. Residues of imazethapyr in soybean grain, straw and soil under application of long term fertilizers in typic haplustert. *Indian Journal of Weed Science*. 2009;41:90-92.
15. Solanki RM, Bhale VB, Zadav KV, Kelaiya GR. Studies on integrated weed management in irrigated groundnut. *Indian Journal of Weed Science*. 2005;37:119-120.
16. Vijay J, Mallareddy M, Shekar K, Reddy TP, Padmaja B. Effect of Sequential Application of Herbicides on Weed Control in Soybean [*Glycine max* (L.) Merrill].



- International Journal of Pure & Applied Bioscience. 2018;6(1):543-546.
17. Dhane JB, Jawale SM, Shaikh AA, Dalavi ND, Dalavi PN. Effect of integrated weed management on yield and economics of soybean [*Glycine max* (L.) Merrill]. Journal of Maharashtra Agricultural Universities. 2009;34(2):141-143.
  18. Kewat ML, Pandey J, Yaduraju NT, Kulshrestha G. Economics and eco-friendly weed management in soybean [*Glycine max* (L.) Merrill]. Indian Journal of Weed Science. 2000;32(3&4): 135-139.
  19. Chemical Fact Sheet For: Pendimethalin (Fact Sheet No. 50). Office of Pesticide Programs, US EPA, Washington, DC; 1985.
  20. WSSA Herbicide Handbook Committee. Herbicide Handbook of the Weed Science Society of America, 6th edition WSSA, Champaign, IL; 1989.
  21. Occupational Health Services, Incorporated. MSDS for Pendimethalin. OHS Incorporated. Secaucus, New Jersey; 1991.
  22. Zulalian J. Study of the absorption, excretion, metabolism, and residues in tissues of rats treated with carbon-14-labeled pendimethalin, PROWL herbicide. Journal of Agricultural and Food Chemistry. 1990;38:1743-1754.

© 2020 Raj et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*  
*The peer review history for this paper can be accessed here:*  
<http://www.sdiarticle4.com/review-history/56648>