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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2020; 9(3): 152-157

www.thepharmajournal.com
Received: 09-01-2020
Accepted: 12-02-2020

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Resource use efficiency in rice cultivation in kharif and summer seasons and impact of summer rice cultivation on ground water and soil fertility in Uttarakhand

Virendra Singh, Aparna Chausali and Om Prakash Maurya

Abstract
This paper makes estimation of input use in rice cultivation in kharif and summer seasons along with resource use efficiency in two seasons. The study also showcases the attitude of farmers towards summer rice cultivation by recording their perception about impact on ground water exploitation and soil fertility. The primary data pertaining to 2015-16 was collected from 90 farmers of Udham Singh Nagar district of Uttarakhand through personal interview. The study revealed that average use of critical inputs such as seed, chemical fertilizers and irrigation was higher in case of summer rice, while the use of human labour, tractor power and plant protection chemicals was higher in case of kharif rice. There existed suboptimal use of these factors and inefficiencies in input use in both the seasons, but the inefficiencies were more pronounced in summer season, indicating more scope for improving yield by intensifying input use. The study stresses that farmers are aware of the ill effects of rice cultivation in summer season on underground water and soil fertility, but in the quest of realizing higher yield they are knowingly overexploiting these resources.

Keywords: Summer rice, input use level, resource use efficiency, farmers' perceptions, marginal value productivity.

Introduction
On account of ever-increasing population, increasing prosperity and changing food habits the demand for food is increasing. The Food and Agriculture Organization has estimated that the world food production will have to rise by 40% by 2030 and 70% by 2050. The limitation of area expansion under cultivation, slowing down food production growth due to declining base of natural resources is the today's cause of concern. The farmers need to produce more food from same or even lesser area keeping accord with the delicate environment. In view of this the only means of increasing the food production is by augmenting the yield of major food crops. Rice along with wheat is the base of Indian food security to meet the country's goal of assuring food for all. Rice alone contributes about 42% of the total food production of the country and about 45% of the total cereal. The rice growing states like Andhra Pradesh, West Bengal, Punjab and Uttar Pradesh have high yield; and contribute about 60% of total rice production. In Indian conditions rice is grown mainly in two seasons, viz. kharif and summer seasons. Presently kharif and summer rice accounts for 89% and 11% of total rice area and 85% and 15% of total rice production (CRRI, 2013) [6], respectively. Summer rice has high yield potential under same fertilizer and land situation in short duration in comparison to kharif rice. Summer rice can be a possible option to increase the rice production, as the yield of this crop has been reported to be much higher than that of kharif rice (Thakur *et al.*, 1994) [5]. Traditionally summer rice was cultivated in river basin deltas of Bangladesh and eastern India including eastern Uttar Pradesh, Bihar, West Bengal and Assam. The practice has been now extended even to those non-traditional areas where sufficient irrigation water is available. According to an estimate of Ministry of Agriculture the area under summer rice in the country is about 3.41 Mha (2014). The summer rice cultivation in Uttarakhand is confined to the districts of Haridwar, Dehradun, and Udham Singh Nagar. The area, production and productivity of summer rice in the year 2010-11 was 0.15 lakh ha, 0.52 lakh tonnes and 33.10 quintals per ha, respectively, while the same of kharif rice was 2.73 lakh ha 54.98 lakh tonnes and 18.20 quintals per ha, respectively in the same year (Mani, 2012). For the last about one and half decades the summer rice cultivation has gained popular in Tarai region; particularly in Udham Singh Nagar district, where short duration varieties of rice are grown after harvesting

vegetable pea in the areas with assured irrigation facilities. The rice cultivation in summer season has gained popularity in Udham Singh Nagar district also on account of good availability of ground water and suitability of environmental conditions. But the expansion of rice cultivation in summer season in the area has raised some concerns; such as decline in soil fertility on account of double cropping of rice in a year on the same piece of land; relegating non-cereal crops such as pulses and oil seeds to the back bench in the cropping pattern; encouragement of insect and pest population, which becomes a big problem for the subsequent crops; and being high water guzzling crop this crop has led over exploitation of groundwater, damaging drinking water. The summer rice cultivation on one hand has potential to harvest more output from fixed production resources, at the same time it leads to over exploitation of soil fertility and water resources and poses threat to them, on the other hand.

The success of this enterprise depends on socio-economic factors such as level of skills and awareness among the farmers, efficient utilization of resources and profitability. Further, a number of studies on economic aspect of rice cultivation have been attempted emphasizing different aspects, but probably no systematic study has been attempted highlighting the difference resource use efficiency in rice cultivation in kharif and summer seasons in an important area for rice cultivation. This called for a study that highlight the difference, if any, in resource use efficiency in rice cultivation in kharif and summer season and also to showcase the farmers' perception about impact of summer rice cultivation on land fertility and ground water exploitation.

Material and Method

The study was conducted in Udham Singh Nagar district of Uttarakhand. Out of seven blocks in the district two blocks with the highest area under rice cultivation in summer season were selected purposively. Further, three villages from each selected block were selected randomly and farmers were identified on the basis of rice cultivation in kharif and summer seasons. A list of farmers taking rice crop both in kharif and summer seasons was prepared for each village separately and a sample of 15 farmers from each village was drawn randomly. Thus, required data was collected from 90 farmers pertaining to year 2014-2015.

To compare the resource use efficiency the Cobb-Douglas production function was fitted separately for rice cultivation in kharif and summer season. Before fitting the function the data was subjected to test multicolinearity between independent variables using zero order correlation matrix. The correlation coefficient between two variables >0.80 was considered as a sign of presence of multicollinearity.

$$Y = aX_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5} X_6^{b_6} e^{\mu}$$

Where,
Y = Yield of rice (q/ha)
X_1= Quantity of seed (kg/ha)
X_2= Expenditure on manures and fertilizers (Rs./ha)
X_3= Irrigation (No.)
X_4= Human labour in (mandays/ha)
X_5 = Machine power (hours/ha)
X_6= Expenditure on plant protection (Rs./ha)
a= Efficiency parameter.
U= Error term
b_i= regression coefficients of the explanatory variables. The same were tested for their significance using usual t-test in the following way;

$$t = \frac{b_i}{SE(b_i)}$$

Where,
b_i = Regression coefficients of i^{th} input
SE (bi) = standard error of i^{th} input
The marginal value productivity of input factors was estimated by multiplying the marginal physical product of the i^{th} input by the unit price of the output as;

$$MVP_{xi} = MPP_{xi} (P_y) \text{ i.e. } MVP_{xi} = b_i \frac{\overline{Y}}{\overline{X}_i} (P_Y)$$

Where,
MPP_{xi} = Marginal Physical Product of i^{th} input
P_y = Price of output per unit (Rs.)
$\overline{Y}$ = Geometric mean of output
$\overline{X}_i$ = Geometric mean of i^{th} input
b_i = Regression coefficient of i^{th} input (i = 1, 2, 3,……, 6)
The marginal input cost (MIC) was worked out taking unit price of the respective input into consideration.
$MIC_{xi} = P_{xi}$

Where,
MIC_{xi} = Marginal Input Cost of i^{th} input
P_{xi} = Unit Price of i^{th} input
The marginal value product (MVP) and marginal input cost (MIC) for each input were compared and the difference of two was tested by computing t statistics, as follows;

$$t = \frac{MVP_{xi} - MIC_{xi}}{SE \text{ of } MVP_{xi}}$$

Where,

$$SE \text{ of } MVP_{xi} = \sqrt{AVP \times V(b_i)}$$

$V(b_i)$ Variance of i^{th} coefficien $t = \frac{\Sigma(X - \overline{X})}{n - 1}$

To know the perception of farmers regarding impact of summer rice cultivation on ground water and soil fertility a five-point scale was developed and used, through which qualitative information collected was converted into a quantitative data. The scale was consisted 18 statements which expressed either favourable or unfavourable attitude towards the given statement to which the respondent was asked to react. Each response was given a numerical score, indicating his favourableness and unfavourableness. To measure the attitude of farmers the scores of each statement were summed up and weighted averages were calculated. The respondents were asked to express their perception of the positive and negative effects of summer rice cultivation in a five point continuum scale containing positive and negative statements. The scores assigned for the analysis of positive and negative perceptions of farmers were as follows:

Perception-wise weightage given to five-point scaling scores

Perception	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
Score	5	4	3	2	1

Note: The score assigned to the statements indicating positive and negative impact of summer rice cultivation

Results and Discussion

Input use levels in rice cultivation in kharif and summer season

The pattern and timeliness of input application in farming in an area is a reflection of technology adoption and status of farming as business. The input use level in rice cultivation in kharif and summer seasons in district Udham Singh Nagar district of Uttarakhand has been presented in table 1. In Indian condition for performing various crop operations use of services of human labour is indispensible, which was partly supplied by the farm family and partly by hiring arrangement from outside farm. Average number of human labour applied in rice cultivation in summer season was found to be 42.65 man days /ha, which was 19.02 per cent less than that in kharif season (52.67 man days /ha). The higher labour employment in kharif crop was attributed to number of weeding operation required in the crop due to more weed emergence in this season. The level of machine (tractor) power use in rice cultivation in kharif season was estimated to be 12.05 hours/ha, which was about nine per cent higher than that in summer crop (11.02 hours/ha). The difference in use of machine power was due to the difference in the condition of soil after harvesting of previous crop. The field preparation for crop in kharif season, which usually takes place during rainy season, takes slightly more machine power hours, because it gets compact if remained fallow during previous season.

Table 1: Input use level and yield of rice in kharif and summer season

S. No.	Particulars	Kharif Season	Summer Season
1	Human labour (man days/ha)	52.67	42.65 (-19.02)
2	Machine power (hours/ha)	12.05	11.02 (-8.55)
3	Seed (Kg/ha)	19.70	22.52 (14.31)
4	Total Fertilizers (Kg/ha)	479.69	503.97 (5.06)
a	Urea (Kg/ha)	272.20	299.57 (10.06)
b	NPK (Kg/ha)	186.19	184.50 (-0.91)
c	Zinc (Kg/ha)	21.30	19.90 (-6.57)
5	Plant protection Chemicals (Kg/ha)	18.63	12.10 (-35.05)
6	Irrigation (Numbers)	7.23	21.90 (202.90)
7	Yield of main product	62.32	76.50 (22.75)

Figures in parentheses indicate the percentage change over kharif rice Table also shows that the seed rate in rice cultivation in summer season (22.52 Kg/ha) was 22.52 per cent higher than that in kharif crop (19.70 Kg/ha). The higher seed rate in case of summer crop was attributed to the poor rate of seed germination on account of low temperature during the period (months of January – February) when nursery for summer crop is established is low. The fertilizer application in rice cultivation in summer season (503.97 Kg/ha) was markedly higher than in kharif season (479.69 Kg/ha). The higher fertilizer application in summer season was due to responsiveness of the crop to higher dose of fertilizer.

It is also evident from the table that the average number of irrigation applied to the crop in kharif season was about seven, whereas the same in case of summer season was as high as 22. The higher number of irrigation applied to summer rice was due to unavailability of natural water from rains and heavy water requirements of crop during summer season on account of higher evaporation and transpiration rates during summer season. Further, the average use of plant protection chemicals in rice cultivation kharif season was estimated to be 18.63 Kg/ha, whereas the same was worked out to be 12.10 Kg/ha in summer season. Higher use of plant protection chemicals in kharif rice was attributed to higher infestation of insects and diseases. The average yield of crop in summer season was 76.50 Qt/ha, which was about 23 higher than that in kharif season (62.32 Qt/ha).

It can be inferred that the average use of critical inputs such as seed, chemical fertilizers and irrigation was higher in case of summer rice, while the use of human labour, tractor power and plant protection chemicals was higher in case of kharif rice. The crop in summer season was responsive to higher doses of critical inputs, hence resulted in higher yield.

Resource use efficiency in rice cultivation in kharif and summer season

To estimate the resource use efficiency in rice cultivation log linear production function was fitted separately for the crop grown in kharif and summer season. The Cobb–Douglas production function included rice yield per hectare as dependent variable and per hectare quantity of seed, human labour employed, machine power used, number of irrigation applied, expenditure made on manures & fertilizers and expenditure made on plant protection chemicals as independent variables. Before fitting the production functions to the data, the data was tested for problem of multicollinearity. The zero order correlation matrices of variables have been presented in appendices I and II.

Elasticities of production of inputs and coefficient of multiple determination

The regression coefficients i.e. production elasticities of different inputs along with the coefficient of multiple determination have been presented in table 2. A perusal of the table indicates that the regression coefficients of seed, fertilizer, irrigation, machine power and plant protection chemicals were found to be positive, implying that seed, fertilizer, irrigation, machine power and plant protection chemicals were found influencing the productivity significantly.

Table 2: Estimated production function for rice cultivation in kharif and summer seasons

S. No.	Variables	Kharif season	Summer season
1.	Constant	0.882 (0.423)	0.602 (0.355)
2.	Seed (Kg)	0.198** (0.048)	0.196* (0.061)
3.	Expenditure on Fertilizers (Rs.)	0.129** (0.0459)	0.135*** (0.044)
4.	Irrigation (No.)	0.073*** (0.019)	0.151** (0.044)
5.	Human labour (Man days)	0.168 (0.037)	0.203** (0.054)
6.	Machine power (Hours)	0.052** (0.033)	0.021 (0.033)
7.	Expenditure on Plant protection chemicals (Rs.)	0.061** (0.035)	0.078** (0.026)
8.	R^2	0.80	0.84

*, **, *** indicate significance at 1 per cent, 5 per cent and 10 per cent probability levels.

Note: figures in parentheses indicate standard errors.

The magnitudes of production elasticities indicate that a one per cent increase in quantity of seed, expenditure on fertilizers, number of irrigation, machine power and expenditure on plant protection chemicals will lead an increase of yield by 0.198 per cent, 0.129 per cent, 0.073 per cent, 0.052 per cent and 0.061 per cent, respectively in rice cultivation in kharif season. Further, the regression coefficients of seed, fertilizer, irrigation, machine power and plant protection chemicals were found to be positive, indicating that seed, fertilizer, irrigation, human labour and plant protection chemicals exercised significant impact on productivity in rice cultivation in summer season. The magnitudes of production elasticities of seed, fertilizer, irrigation, human labour and plant protection chemicals indicate that a one per cent increase in seed, expenditure on fertilizer, number of irrigation, human labour and expenditure on plant protection chemicals led an increase in the yield by 0.196 per cent, 0.135 per cent, 0.151 per cent, 0.203 per cent and 0.078 per cent, respectively.

Marginal value productivity of inputs rice cultivation in kharif and summer seasons

The marginal value products of various inputs at their geometric mean level holding other variables constant in rice cultivation in kharif and summer season for the sample farmers has been presented in table 3.

Table 3: Marginal value productivities (MVPs) of inputs in rice cultivation

S. No.	Variables	Kharif season	Summer season
1	Seed (Kg)	311.97* (35.35)	336.15* (36.33)
2	Expenditure on Fertilizers (Rs.)	1.29 (1.00)	1.53* (1.00)
3	Irrigation (No.)	174.15* (148.3)	263.05* (153.00)
4	Human labour (Man days)	207.97 (250.00)	289.57* (250.00)
5	Machine power (Hours)	96.77 (800.00)	45.19 (800.00)
6	Expenditure on Plant protection chemicals (Rs.)	3.60* (1.00)	5.40* (1.00)

* indicate significance at 1 percent level of significance

Note: figures in parentheses indicate acquisition cost of respective input.

A view on the table 3 shows that the marginal productivities of seed, expenditure on fertilizers, irrigation, machine power and expenditure on plant protection chemicals, which exercised positive impact on rice yield, in kharif season were Rs.311.97, Rs.1.29, Rs.174.15, Rs.207.97, Rs.96.77 and Rs.3.60, respectively. A comparison of acquisition costs with their marginal value products show that marginal value products of seed, irrigation and expenditure on plant protection chemicals only were significantly higher than acquisition costs, implying a scope of increasing yield of rice through increasing seed rate, number of irrigation applied and expenditure made on plant protection chemicals kharif season. Table 3 also shows that the marginal productivities of quantity of seed, expenditure on fertilizers, irrigation, human labour and expenditure on plant protection chemicals, which had positive impact on yield of rice, were Rs.336.15, Rs.1.53, 263.05, Rs.289.57 and Rs.5.40, respectively in summer season. A comparison of the acquisition costs with their marginal value products show that the marginal value products of only seed, expenditure made on fertilizers, number of irrigation applied, human labour and expenditure made on plant protection chemicals were significantly higher than their acquisition costs, implying that yield of rice could be increased through increasing seed rate, expenditure made on fertilizers, number of irrigation applied, human labour and expenditure made on plant protection chemicals in summer season.

An analysis of marginal value productivities of inputs in rice cultivation reveal that inputs were sub-optimally used i.e. there existed inefficiencies in input use in both the seasons, but the inefficiencies were more pronounced in summer season, indicating more scope for increasing production by increasing input use to their optimum level.

Farmers' perception about impact of rice cultivation in summer season on ground water exploitation and soil fertility

While taking crop decision most of the farmers look at profitability before taking them up as enterprise. The cultivation of rice in summer season is gaining popularity over years on account of higher productivity, but on the hand it requires a lot of irrigation water, which leads even excess exploitation of underground water in the areas where surface water is scarcer. Also continuous cultivation of summer rice in the same field results in damage of soil structure and reducing the soil fertility. Depending on the positive and negative aspects of rice cultivation in summer season the farmers were asked to express their perception, which were recorded on a five-point scale containing negative and positive statements. In each statement the farmers were asked to give their opinion in any one point on the scale i.e. strongly agree, agree, undecided (neutral), disagree, strongly disagree.

Positive perceptions

Farmers' positive perception about impact of rice cultivation in summer season has been presented in the table 4. A look on the table reveals that all farmers agreed that the productivity of rice in summer season is higher than that in kharif season. About 82 per cent of farmers agreed that the returns from rice cultivation in summer season are greater than that from the same in kharif season, whereas more than 61 per cent of the farmers consented that rice cultivation in summer season enhances the income of them due to higher realizable returns from it. The returns are not only higher than that from rice in kharif season, but also higher than that from other crops grown in summer season.

Table 4: Positive perception about impact of rice cultivation in summer season

S. No.	Statements	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree	Weighted average
1	Rice productivity in summer season is higher than that in Kharif season	69 (76.66)	21 (23.33)	0 (0.00)	0 (0.00)	0 (0.00)	4.75
2	Rice cultivation in summer season improves the economy of farmers	5 (5.55)	50 (55.55)	27 (30.00)	5 (5.55)	3 (3.33)	3.54
3	Rice cultivation in summer season leads to higher cropping intensity	1 (1.11)	49 (54.44)	39 (43.33)	1 (1.11)	0 (0.00)	3.56
4	Water management is easy in rice cultivation in summer season	31 (34.44)	28 (31.11)	27 (30.00)	2 (2.22)	2 (2.22)	3.93
5	Summer rice fetch high price in the market because it is off season	6 (6.66)	8 (8.88)	16 (17.78)	16 (17.78)	44 (48.89)	2.00
6	Rice crop in summer season responds well to higher doses of fertilizers.	64 (71.11)	12 (13.33)	3 (3.33)	5 (5.55)	6 (6.66)	4.30
7	Rice is grown in summer season because its maturation period after transplanting is short.	10 (11.10)	33 (36.66)	40 (44.44)	3 (3.33)	4 (4.44)	3.40
8	Rice crop in summer season is less susceptible to pests and insects	42 (46.66)	30 (33.33)	12 (13.33)	1 (1.11)	5 (5.55)	4.10
9	Returns from rice in summer season is higher than in kharif season	43 (47.77)	39 (43.33)	3 (3.33)	5 (5.55)	0 (0.00)	4.30

Figures in parentheses indicate the percentage of respective category.

More than 55 per cent farmers were of the view that rice cultivation in summer season leads to higher cropping intensity. About half (49 per cent) of the farmers differed with the statement that rice in summer season fetches higher price in the market than in kharif season. More than 84 per cent of farmers confirmed that rice cultivation in summer season responds well to higher doses of fertilizers, they believe that the productivity of crop can be further increased by applying more or higher doses fertilizer in summer season. About 80 per cent of farmers were of the opinion that insect and pest infestation in the crop in summer season is less. They felt that it is primarily due to high temperature during summers, because of which insects and pests undergo in the dormant stage and not harming the crop. Nearly 48 per cent farmers opined that they undertook rice cultivation in summer season because of the short duration of the crop, which enables them to adjust three crops in a year easily.

Weighted mean of farmers' perception about positive impact of rice cultivation in summer season was calculated for every statement. The highest weighted average of the statement 'the productivity of rice in summer season is higher than that in kharif season' indicates that rice cultivation in summer season is done in the area because of its higher productivity. The weighted averages of other positive statements also imply that the returns from rice cultivation in summer season and its less susceptibility to insects and pests are the pertinent reasons for its popularity in the area.

Negative perceptions

More than 60 per cent of the farmers agreed that growing rice twice in a year in the same field leads to compaction of soil and formation of hard pans, deteriorating the soil structure. Since growing rice needs intensive field preparation and the frequent use of heavy machinery; continuous use of machinery destroys the soil structure, making it harder than before. Around 97 per cent of farmers agreed that growing rice twice in the same field makes the soil row and impairing soil health and decreases the productivity of the soil. Nearly 89 per cent farmers were of the opinion that rice cultivation in summer season needs continuous irrigation till it matures because lack of water deteriorates the grain quality of the crop. More than 93 per cent farmers said that rice cultivation in summer season exploits more underground water because it a water guzzling crop, while about 89 per cent of farmers agreed that rice cultivation in summer season requires more irrigation water than that in kharif season. The farmers expressed that it is because the water requirement in kharif season is partly met by the rains. Around 90 per cent respondents opined that rice cultivation in summer season needs more water because of greater water loss in summer season due to higher evaporation and transpiration rates, which is compensated by providing additional irrigation. About 86 per cent farmers confirmed the statement that rice cultivation in summer season increases the pest and insect attack in kharif season, as rice crop in season summer serves as host for the insects and pests to be in the dormant phase, and under the favourable condition (during monsoon season) they burst out and attack on the successive crop(s) at a greater intensity than before.

Table 5: Negative perception about impact of rice cultivation in summer season

S. No.	Statements	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree	Weighted average
1	Frequent tillage by heavy machinery leads to formation of plough pan and compaction of soil on account of mono-cropping.	55 (61.11)	31 (34.44)	4 (4.44)	0(0.00)	0 (0.00)	4.50
2	Rice crop in summer season over-exploits the underground water resources	66 (73.33)	18 (20.00)	4 (4.44)	1(1.11)	1 (1.11)	4.60
3	Mono-cropping of rice makes the soil row	67 (74.44)	20 (22.22)	1 (1.11)	2(2.22)	0 (0.00)	4.60
4	Rice cultivation in summer season increases insects and pest attack in Kharif crop	27 (30.00)	50 (55.55)	10 (11.11)	2 (2.22)	1 (1.11)	4.30
5	Rice cultivation in summer season needs huge amount of water	45 (50.00)	35 (38.89)	6 (6.67)	0 (0)	4 (4.44)	4.20
6	Water requirement of rice crop in summer season is higher than Kharif season.	43 (47.78)	39 (43.33)	3 (3.33)	5 (5.55)	0 (0.00)	4.30
7	Rice cultivation in summer season leads to deficiency of micro nutrients in soil	38 (42.22)	46 (51.11)	6 (6.66)	0 (0.00)	0 (0.00)	3.40
8	Water loss in rice cultivation in summer season is due to high transpiration and evaporation rates.	50 (55.55)	31 (34.44)	5 (5.55)	2 (2.22)	1 (1.11)	4.10
9	Mono-cropping of rice results in excessive use of fertilizers and pesticides causing water and soil pollution	9 (10.00)	48 (53.33)	30 (33.33)	1 (1.11)	0 (0.00)	4.30

Figures in parentheses indicate the percentage of respective category

More than 83 per cent farmers confirmed that repetitive cropping of rice increases the use of fertilizers and pesticides, resulting in water and soil pollution. More than 93 per cent farmers opined that growing the rice twice in a year leads deficiency of micronutrients in the soil. Due to deficiency of nutrients crops suffer from a disorders and lead to lower yield than the potential.

It is also clear from the table that the highest weighted mean score of statements 'rice cultivation in summer season over-exploits the underground water resources' and 'mono-cropping of rice makes the soil row' conclude that rice cultivation in summer season exploits the underground water to larger extent and also it is highly responsible for degrading soil fertility. Other statements too scored around the highest score.

It can be inferred that despite of knowledge of negative effects of rice cultivation in summer season on soil fertility and underground water, the farmers are cultivating the crop on the cost of depletion of precious natural resources and expanding area over years.

Conclusion

Higher productivity of rice by applying higher doses of input in summer season serves as an incentive, but leads over exploitation of ground water and impairment of soil fertility. The perception of the farmers stresses that farmers are aware of ill effects of rice cultivation in summer season on underground water and soil fertility, but in the quest of realizing higher yield they are knowingly overexploiting the natural resources. Water crisis and food scarcity are global issues; none of them can be compromised; both are indispensible for survival of future generations. This calls for policy instruments to stop over exploitation of water and land resource or invention of innovative methods of use to reconcile conflicting objectives for sustainable development of society.

Acknowledgement

Authors are thankful to all farmers-respondents for proving needed data and all those who helped in preparation of this manuscript.

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