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Vol. 41 No. 1 June 2015 Page No.

Contents

Short Notes

Himachal Journal of Agricultural Research 41(1): 1-5 (2015)

Vegetable grafting: a boon to vegetable growers to combat biotic and abiotic stresses

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Abstract

Grafting is an alternative approach used in vegetable production to fight against soil-borne diseases such as *Fusarium* wilt, bacterial wilt and nematodes since 1920s in Japan and Korea. Grafting as a technology for the commercial production was later on adopted by many countries in Europe, Middle East, Northern Africa, Central America and other parts of Asia. For the production of many fruit-bearing vegetables which include watermelon, cucumber, melon, tomato, eggplant and pepper, grafted seedlings were used. These seedlings besides providing resistance against biotic/abiotic stresses, increase the yield of the cultivars. This technique is considered eco-friendly for sustainable vegetable production because the resistant rootstock reduces dependence on agrochemicals. Grafting improves quality of the plant and is used to induce resistance against low and high temperatures. Growth, yield and fruit quality of the scion is greatly influenced by the type of rootstock used. Due to high post graft mortality of seedlings, this technology is still in infancy in India. For its commercial application in India, sharpening of grafting skills and healing environment need to be standardized.

Key words: Grafting, advantages, methods, basic pre-requisites, precautions

Grafting is a method of propagation where two pieces of living plant tissues are joined together to develop as a single plant. The first attempt in vegetable grafting was done by grafting watermelon (*Citrullus lanatus*) onto pumpkin (*Cucurbita moschata*) rootstock in Japan and Korea in the late 1920s (Lee 1994). A serious crop loss caused by soil-borne diseases aggravated by successive cropping was avoided by production of vegetables with grafted seedlings. In many fruit-bearing vegetables such as watermelon, cucumber, melon, tomato, eggplant and pepper, the use of grafted seedling has become increasingly popular. Grafting is an environment-friendly approach which is used to control soil borne diseases and increasing the yield of susceptible cultivars (Lee and Oda 2003). This technique is eco-friendly for sustainable vegetable production and by using resistant rootstock, it reduces dependence on agrochemicals (Rivard et al. 2008). To induce resistance against low and high temperatures, grafts were generally used (Venema 2008). Grafting increases the yield and promotes biotic/abiotic stress tolerance. Grafting is also used to induce tolerance to abiotic stresses *viz*. flooding, drought and salinity. In Japan (92%), Korea (98%) and China (20%), major share in watermelon production is from grafted seedlings. In Europe, Spain is leading in grafted seedlings production with 129 million grafted seedlings followed by Italy (47 million grafted seedlings) and France (28 million grafted seedlings) (FAO 2009). Grafting as a technology for the commercial production of vegetables was later on adopted by many countries in Europe, Middle East, Northern Africa, Central America and other parts of Asia (Kubota *et al*. 2008).

In India, grafting work has been started in IIHR Bangalore by Dr RM Bhatt and his associates. Their work was on identification of rootstocks for waterlogged conditions. For this purpose they have imported semiautomated grafting machine. IIHR Bangalore organized first ever short course on vegetable grafting during the year 2013. NBPGR regional station, Thrissur, Kerala have done work on Cucurbit grafting by taking *Momordica cochinchinensis*, a dioecious plant. The female plants were grafted on to the male plants to increase its production. Graft success was 98%. CSKHPKV, Palampur initiated work on grafting and identified more than 22 rootstocks of brinjal, chilli, tomato and cucurbits for importing resistance to bacterial wilt and nematodes. Some

private players are also involved in grafting. One of them is 'VNR Seed Private Limited' in Chhattisgarh which is supplying grafted brinjal seedlings resistant to bacterial wilt to farmers. The other seed company is 'TAKII SEED INDIA PRIVATE LIMITED'.

Advantages of grafting

Tolerance to soil-borne diseases: Grafting is used to get rid of soil-borne diseases such as *Fusarium* wilt in Cucurbitaceous crops (cucumber, melon etc.) and Bacterial wilt in Solanaceous crops (tomato, pepper etc.) (Oda *et al*. 1999). Grafting is a quick method in melon for controlling race 1 and 2 of *Fusarium oxysporum f. melonis* (Nisini *et al.* 2002). Grafting is an effective tool for disease resistance by using rootstocks resistant to both *Phytophthora* blight and bacterial wilt. Pepper scion ('Nokkwang') grafting onto breeding lines ('PR 920', and 'PR 921', and 'PR 922') resistant to both *Phytophthora* blight and bacterial wilt showed greater rate of survival when they were inoculated with *Phytophthora capsici* and *Ralstonia solanacearum* (Jang *et al*. 2012). When the susceptible commercial pepper variety (cv. Gedon) grafted onto rootstocks resistant to *Rhizoctonia* root rot and *Fusarium* wilt grown in the infested soil was less attacked with wilt disease, while ungrafted plants were severely infected (Attia *et al*. 2003).

Tolerance to abiotic stresses: To induce resistance against low and high temperature, grafts were generally used**.** For the production of fruiting vegetables under the winter greenhouse conditions, tolerance to extreme temperature is crucial (Venema 2008**)**. Figleaf gourd rootstock has been used commercially to increase the tolerance of cucumber, watermelon, melon and summer squash to low soil temperature. Grafting led to salt and flooding tolerance (Yetisir *et al*. 2006), improved water use efficiency (Rouphael *et al*. 2008), increased nutrient uptake (Colla 2010) and alkalinity tolerance (Colla *et al*. 2010). Grafting helps in the survival of plants under low temperature because of the presence of more content of Linolenic acid. Chilli gave highest yield under high-temperature conditions when grafted on sweet pepper rootstocks (Palada and Wu 2008). Grafting minimizes the negative effect of boron, copper, cadmium, and manganese toxicity (Savvas *et al*. 2008). In tomato, grafting resulted in the formation of more number of internodes and flowers in outdoor cultivation and number and total weight of fruits in indoor cultivation (Voutsela *et al*. 2012).

Under the conditions of deficit irrigation, watermelons grafted onto a commercial rootstock (PS 1313': *Cucurbita maxima* Duchesne x *Cucurbita moschata* Duchesne), gave 60% more marketable yield than ungrafted melons (Rouphael et al. 2008). Drought tolerance that was provided by either the rootstock or the scion resulted in increased nitrogen fixation in soybean (*Glycine max* L.) (Serraj and Sinclair 1996). Transgenic tobacco plants were successfully generated by maintaining photosynthetic activity and high water contents during drought (Rivero et al. 2007). Grafting improved flooding tolerance of bitter gourd (*Momordia charanthia* L. cv. New Known), when it was grafted onto luffa (*Luffa cylindrica* Roem cv. Cylinder) (Liao and Lin 1996). In the lowland tropics flooding occurs during the heat period. The AVRDC recommends growing tomatoes on eggplants 'EG195' or 'EG203' and pepper on chilli accessions 'PP0237-7502','PP0242-62' and 'Lee B' (AVRDC 2003 & 2009).

Effect on fruit quality: Grafting is an effective approach to improve fruit quality under both optimum growth conditions and salinity. The fruit quality of the shoot, at least partially, depends on the root system (Flores *et al*. 2010). In soilless tomato cultivation, grafted plants had higher marketable yield, fruit quality and pH content of fruits depending on rootstocks (Gebologlu *et al*. 2011). Grafting of eggplant onto *S. torvum* increased the fruit size and had no effect on quality and yield. The fruit size of watermelons grafted to rootstock having vigorous root systems was significantly increased as compared to the fruit from intact plants.

In cucumbers, especially for export, bloom development and external colour are important quality factors. These can be greatly influenced by the rootstock. The grafting technique affects various quality aspects of vegetables. Rootstock/scion combinations should be carefully selected for specific climate and geographic conditions. Appropriate selection can help to control soil borne diseases and also increases yield and fruit quality. Sugar, flavour, pH, color, carotenoid content and texture can be affected by grafting and the type of rootstock used (Davis et *al.* 2008).

Plant vigour promotion: The root systems of selected rootstocks, much larger and more vigorous, can absorb water and nutrients more efficiently as compared to non-grafted plants. In cucumber, vigorous root system of the rootstock can effectively absorb water so that less frequent irrigation may be practiced. By using vigorous rootstocks the frequency of agrochemical application can be significantly reduced. In watermelons, the amount of chemical fertilizers can be reduced to about one-half to two-third as compared to the standard recommendation for the non-grafted plants (Salehi-Mohammadi *et al*. 2009).

High yield: When plants are cultivated in problematic

soils, grafts have been used to improve yield (Kacjan-Marsic and Osvald 2004). They found higher yield of tomato cv. 'Monroe' grafted onto rootstock of 'Beaufort'. In greenhouse as well as in open-field, grafted plants gave more yield than non-grafted ones (Khah *et al*. 2006). Tomato plants grafted onto 'Heman' and 'Primavera' produced higher yield in the greenhouse and the open field. Water use efficiency and yield were higher in grafted plants. The researchers of Korea and Japan have reported increases of 25 to 50% in yield of grafted tomato, melons, pepper, eggplant and watermelon compared to non-grafted plants.

Methods of Vegetable Grafting

A number of grafting techniques are employed in fruit bearing vegetables. Tomato and eggplants are mostly grafted by cleft and tube grafting. Tongue approach is used in grafting cucurbitaceae especially for cucumber. Slant-cut grafting is easier and has recently become popular for watermelon and melon. This method was developed mainly for robotic grafting. These methods have been discussed as under:

Cleft grafting: The seeds of the rootstock are sown 5-7 days earlier than those of the scion. The stem of the scion (at four leaf stage) are cut at right angle with 2-3 leaves remaining on the stem. The rootstock (at the four to five-leaf stage) are cut at right angles, with 2-3 leaves remaining on the stem. The stem of the scion is cut in a wedge, and the tapered end fitted into a cleft cut in the end of the rootstock. The graft is then held firm with a plastic clip. Move the tray filled with grafted plants to proceed for healing up.

Tube or Japanese Grafting: This grafting has been developed for vegetable seedlings grown by plug culture. This method makes possible to graft small plants grown in plug trays two or three times faster than the conventional method. The smaller the plants, the more plants can be fitted into healing chambers or acclimation rooms. Cut rootstock under cotyledons in a 45^{o} or sharper angle. Prepare the scion with matching hypocotyl width cut in the same angle at about 5- 10 mm below the cotyledons. Place one tube a half way down on top of the cut end of rootstock hypocotyl. Insert the scion into the grafting tube so that cut surface aligns perfectly with that of rootstock. Move the tray filled with grafted plants to proceed for healing up to 7 days.

Tongue Approach Grafting: In this method, seeds of cucumber are sown 10-13 days before grafting and pumpkin seeds 7-10 days before grafting, to ensure uniformity in the diameter of the hypocotyls of the scion and rootstock. The shoot apex of the rootstock is removed so that the shoot cannot grow. The hypocotyls of the scion and rootstock are cut in such a way that they tongue into each other and the graft is secured with a plastic clip. The hypocotyl of the scion is left to heal for 3-4 days and then crushed between the fingers. The hypocotyl is cut off with the razor blade three or four days after being crushed.

Slant-Cut Grafting: This grafting technique is easy to practice and has become popular. This method is mainly developed for robotic grafting. It is important to remove the 1^{st} leaf and lateral buds when a cotyledon of rootstock is cut on a slant.

Basic pre-requisites

Root stocks and scion: Select the desirable rootstock and scion at two true leaf stage. Stem diameter of scion should be same as that of rootstock.

Compatibility: Callous formation takes place between scion and root stock and rebuilding of vascular bundles i.e. cambium formation between the graft union.

Grafting Aids: A. Grafting clips, B. Tubes, C. Pins, and D. Grafting Blade**.**

Screen house**:** Used for growing seedlings prior to grafting. It should be constructed with 60-mesh nylon net. Arrange double door, the upper half of the structure should be covered with a separate UV resistant polyethylene to prevent UV light penetration.

Healing chamber/Grafting chamber: It is used for formation of better graft union. In this chamber grafts should be kept for 5-7 days. Reduces water stress by reducing transpiration, maintains high humidity, maintains optimum temperature and reduces light intensity.

Healing conditions: Healing is the most critical process of grafted seedling production.Temperature of 25-30 ^{o}C, RH-85-90% and low light intensity are required for healing.

Acclimatization chamber**:** This chamber is used for hardening the grafted seedling prior to transplanting to prevent leaf burning and wilting. The grafted seedling takes 7 to 10 days for acclimatization as hardening treatment.

Precautions

To maximize the efficiency of the technique, a perfect co-ordination of the vegetative cycles must be achieved before the conjunction of the two plants. Expose seedlings to full sun and some water stress before grafting to keep the plants short and increase tolerance to water stress. During grafting, timing of the operations needs to be strictly controlled. Make grafts early or late in the day to avoid water loss. Appropriate sanitation measures have to be adopted (use of pest free high quality seeds and sub-

Always match scions and rootstocks of equal stem diameter. Cut them at exactly the same angle. Graft in a location that is protected from direct sunlight and away from greenhouse heater discharge. Make sure the cut surfaces make good contact when the plants are clipped together so that they have the best chance of successfully connecting to each other. Use physical barriers against virus vectors and specific pesticides against insects and fungi. During the entire process the environmental conditions (temperature, humidity, composition of the substrate, sun radiation, ventilation) have to be optimized and controlled.

Future prospects

Identification of compatible disease resistant rootstocks with tolerance to abiotic stresses is the basic requirement for continued success. Healthy grafted seedlings at reasonable price is the key point for wider use. Methods/ techniques should be of low cost so that these could be adopted by farmers for commercial production. More research is needed to minimize post grafting losses. There is a scope for vegetable breeders and private companies of India to develop resistant rootstocks. The companies should be involved in marketing these rootstocks to the field e.g. Dai power: Rootstock for Capsicum and Chilli. It is tolerant to diseases like Bacterial wilt, Phytophthora blight, Mosiac virus. Researches, extension specialists and seed companies need to work together to integrate this modernized technology as an effective tool for producing high-quality vegetables. Sharpening of grafting skills and healing environment need to be standardized for its application on commercial scale.

Conclusion

Grafting provides a site specific management tool for soil borne diseases. Grafting can affect various quality aspects of vegetables. Rootstock/scion combinations should be carefully selected for specific and geographic conditions. It fits well into the organic and integrated crop production system. It reduces the need for soil disinfectants and thereby environmental pollution. Grafting technology has a potential in promotion of cultivation in non-traditional and fragile agro-eco system. Grafting is a rapid alternative tool to the relatively slow breeding methodology aimed at increasing biotic and abiotic stress tolerance of fruit vegetables. Since grafting gives increased disease tolerance and vigour to crops, it will be useful in the low-input sustainable horticulture of the future.

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Himachal Journal of Agricultural Research 41(1): 6-12 (2015)

Impact of rainfall on area and production of *rabi* oilseed crops in Himachal Pradesh

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Abstract

The present study was carried out to assess the impact of rainfall on the spread, production and yields of *rabi* oilseed crops in Himachal Pradesh during the past forty years (1968-69 to 2007-08). Year-wise trend analysis in rapeseed-mustard indicated a significant increase in area, production and productivity while a significant decrease was observed in linseed with time. Pentad-wise shift indicated 71.7% increase in the area under rapeseed-mustard during 8th pentad over 1st pentad which might be due to 92.6% increase in rain fall during 8th pentad over 1st pentad. The technological inputs including improved varieties resulted in 105.6% increase in production and 20.4% increase in productivity. Pentad-wise shift in rapeseed-mustard area also exhibited a significant positive correlation with rainfall. In linseed, pentad-wise shift indicated a drastic reduction in area (78.8%), production (89.3%) and productivity (51.2%) during 8th pentad over 1st pentad. There was a negative and non-significant correlation of area with rainfall. The study indicates that under rainfed conditions, the farmers preferred rapeseed-mustard over linseed. Linear regression analysis indicated that the increase in seasonal rainfall may not be the sole reason for area expansion in rapeseed-mustard. On the other hand, a much part of variation in area as well as production in linseed appeared be due to variation in seasonal rainfall.

Key words: Area, production, rapeseed-mustard, linseed, rainfall, Mann-Kendall trend test

Oilseeds being a rich source of fats and vitamins, occupy an important position in Indian agricultural economy and daily diet. The diverse agro-ecological conditions in the country are favourable for growing the seven edible oilseeds (groundnut, rapeseed-mustard, soybean, sunflower, sesame, safflower and niger) and two non-edible oilseeds (castor and linseed). India is the fifth largest vegetable oil economy in the world, next only to USA, China, Brazil and Argentina and has an annual turnover of about INR 80000 crores. India accounts for 12-15% of oilseeds area, 6-7% of vegetable oils production, 9-11% of the total edible oils consumption and 14% of vegetable oil imports. India has imported 51% of her requirements at a huge cost of INR 56910 crores during 2013-14 (Anonymous, 2015). India ranks first in the production of groundnut, second in rapeseed-mustard and fifth in soybean and thus, oilseed crops contribute a significant proportion to the agricultural GDP. The per capita consumption of edible oils in the country has witnessed a steep rise due to rise in population, change in life style, rising per capita income, availability of cheaper edible oil, luxuriant intake of edible oils and the consumer friendly import tariff policy which has resulted in dependency on imports to meet the additional requirement. The area expansion in oilseeds during the last two and half decades was a major source of growth in oilseeds production (Hegde, 2012).

In Himachal Pradesh, the major oilseed crops (rapeseed-mustard, sesame and linseed) are grown over an area of 13.0 thousand ha. Of which nearly 74.6% area is occupied by *rabi* oilseed crops *viz*., rapeseed-mustard and linseed. Rapeseed-mustard group of crops are grown over an area of 9.0 thousand ha with a total production of 2.4 thousand tonnes

and productivity 267 kg/ha (Anonymous, 2012). Based upon the average data over the past ten years (1998-99 to 2007-08), rapeseed-mustard and linseed crops have accounted for 59.8 and 12.5% area under total oilseeds and contributed about 63.8 and 7.0% to the total oilseeds production in the state, respectively. The present investigation aims to understand the inter-relations between changes in spread, production and productivity of *rabi* oilseed crops *vis-a-vis* rainfall pattern during past forty years (1968-69 to 2007-08).

Material and Methods

The area, production and productivity statistics of rapeseed- mustard and linseed for forty crop seasons were taken from the 'Statistical Outline of Himachal Pradesh'. The data on winter rainfall for the same period were collected from Indian Meteorological Department, Pune. To quantify whether trends appear particularly severe during a particular time interval of the reference period, the whole period was split into eight pentads (five years period each) *viz.*, 1968 - 69 to 1972-73, 1973-74 to 1977-78, 1978-79 to 1982-83, 1983-84 to 1987-88, 1988-89 to 1992 -93, 1993-94 to 1997-98, 1998-99 to 2002-03 and 2003-04 to 2007-08 and the spatio-temporal changes in area, production and productivity *vis-a-vis* rainfall were worked out. Year-wise trend analysis was done for area, production and productivity by following Mann-Kendall (Mann, 1945 and Kendall, 1975) non-parametric trend test. This is a statistical method used to study the spatial variation and temporal trends of hydro-climatic series. A non-parametric test is taken into consideration over the parametric one since it can evade the problem roused by data skewness (Smith, 2000).

Mann-Kendall trend test: The test is often used in hypothesis testing (e.g. existence of trends) and therefore, considered as confirmatory data analysis tool.

Let: $x_1, \ldots, x_n$ be a sequence of measurements over time, to test the null hypothesis,

H_0 : $x_1, \ldots, x_n$ come from a population where the random variables are independent and identically distributed,

H_1 : $x_1, \ldots, x_n$ follow a monotonic (e.g. increasing or decreasing) trend over time.

The Mann-Kendall test statistic is calculated as

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \operatorname{sgn}(x_j - x_k) \qquad \text{where}$$

$$\operatorname{sgn}(x_j - x_k) = \begin{cases} 1 & \text{if } x_j - x_k > 0 \\ 0 & \text{if } x_j - x_k = 0 \\ -1 & \text{if } x_j - x_k < 0 \end{cases}$$

S is asymptotically normally distributed.

The mean and variance of S are given by

$$E(S) = 0$$

$$Var(S) = \begin{cases} \dfrac{\left\{ n(n-1)(2n+5) - \sum_{j=1}^{p} t_j (t_j - 1)(2t_j + 5) \right\}}{18} & \text{if ties} \\ \dfrac{\{n(n-1)(2n+5)\}}{18} & \text{no ties} \end{cases}$$

where *p* is the number of tied groups in the data set and t_j is the number of data points in the *j*th tied group. A positive value of *S* indicates that there is an upward (increasing) trend (e.g. observations increase with time) while the negative value of S means that there is a downward (decreasing) trend. If *S* is significantly different from zero, then based on the data H_0 can be rejected at a pre-selected significance level and the existence of a monotonic trend can be accepted.

S is a count of the number of times $x_j - x_k > 0$ for $j > k$, more than $x_{j—} x_k$.

The maximum value of S (called it D) occurs when $x_1 < x_2 < \ldots < x_n$

Kendall's tau is defined as tau = S/D where

$$D = \begin{cases} \sqrt{\left\{ \dfrac{n(n-1)}{2} - \sum_{j=1}^{p} t_j (t_j - 1) \right\}} \sqrt{\left(\dfrac{n(n-1)}{2} \right)} & \text{if ties} \\ \dfrac{n(n-1)}{2} & \text{noties} \end{cases}$$

A positive value of *tau* indicates that there is an upward (increasing) trend while a negative value of *tau* means that there is a downward (decreasing) trend. If *tau* is significantly different from zero (e.g. value < 0.05 at 5% significance level or < 0.01 at 1% significance level), then based on the data, H_0 can be rejected at a pre-selected significance level (alpha = 5%) and the existence of a monotonic trend can be accepted. Besides, Sen's Slope Estimator was used for the determination of trend and slope magnitude (Sen, 1968).

Crop Dominance Index (D_i): Dominance indices were calculated for depicting the expansion of crops with time (Tonhasca, 1993).

$D_i = N_i / N_T$, where N_i is the spread (thousand hectares) of the *i*th crop and N_T equals the total spread.

Linear regression analysis: Linear regression models were estimated with all residuals and fit plots were auto-generated using SAS Software. Simple correlation was used to study association among different variables (Panse and Sukhatme, 1985).

Results and Discussion

Crop-wise area, production and productivity (average of forty crop seasons) revealed that the rapeseed-mustard occupied 1st position in terms of area (7.4 thousand ha), production (2.6 thousand tonnes) and productivity (342 kg/ ha) followed by linseed which exhibited an area of 4.3 thousand ha, production 1.6 thousand tonnes and productivity 335 kg/ha (Fig.1). Perusal of individual year's data revealed that in rapeseed-mustard, the maximum area (9.7 thousand hectares) and production (4.9 thousand tonnes) were recorded during the year 1999-2000 while in linseed, maximum area was covered during 1972-73 (6.9 thousand ha) and the maximum production (3.7 thousand tonnes) and productivity (561 kg/ha) were recorded during 1973-74.

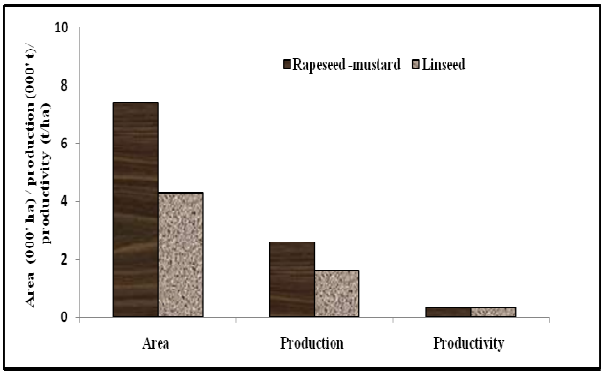

Fig 1. Area, production and productivity of *rabi* oilseed crops in Himachal Pradesh

Trend analysis in area, production and productivity

Year-wise trend analysis indicated a significant increase in area, production and productivity in rapeseed-mustard (Table 1a). A gradual increase in area from 5.3 thousand ha during 1st pentad (1968-69 to 1972-73) to 9.1 thousand ha during last pentad (2003-04 to 2007-08) was also noticed (Fig. 2). Pentad-wise trend analysis also indicated a significant increase in area while no trend in production and productivity was observed (Table 1b).

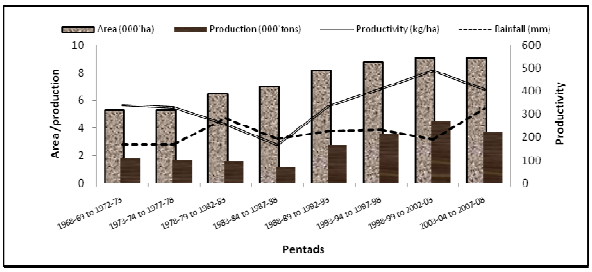

Fig 2. Pentad-wise rainfall, area, production and productivity in rapeseed-mustard

Table 1a. Year-wise trend analysis in area, production and productivity of *rabi* oilseed crops

Variable	Mann-Kendall's statistic (S)	Kendall's Tau	Var. (S)	p value Two-tailed test	Interpretation
		Rapeseed-mustard			
Area (000'ha)	573.0	0.705	7908.3	<0.0001	Increasing trend
Prod. (000'tonnes)	361.0	0.444	7913.0	<0.0001	Increasing trend
Productivity (kg/ha)	178.0	0.217	7924.7	0.047	Increasing trend
		Linseed			
Area (000'ha)	-737.0	-0.906	7912.3	<0.0001	Decreasing trend
Prod. (000'tonnes)	-566.0	-0.701	7892.7	<0.0001	Decreasing trend
Productivity (kg/ha)	-425.0	-0.522	7909.7	<0.0001	Decreasing trend

Pentad-wise gradual decrease in production from 1st (1.8 thousand tonnes) to 4th pentad (1.2 thousand tonnes) followed by rapid increase thereafter up to 7th pentad (4.5 thousand tonnes) was observed and as a result, no trend in production and productivity of rapeseed- mustard was indicated by Mann-Kendall's trend test. On the other hand, both year-wise and pentad-wise trend analysis indicated a significant decrease in area, production and productivity in linseed.

Pentad-wise per cent shift in area, production, productivity and rainfall

Rapeseed-mustard

Pentad-wise percent shift indicated that the area under rapeseed-mustard showed an increase of 71.7% during 8th pentad over 1st pentad (Table 2). Since majority of the *rabi* crops are raised under rainfed conditions, the increase in area might be due to 92.6% increase in rainfall

Table 1b. Pentad-wise trend analysis in area, production and productivity of *rabi* oilseed crops

Variable	Mann-Kendall's statistic (S)	Kendall's Tau	Var. (S)	p value Two-tailed test	Interpretation
		Rapeseed-mustard			
Area (000'ha)	26.00	0.929	0.000	0.000	Increasing trend
Prod. (000'tonnes)	14.00	0.500	0.000	0.109	No trend
Productivity (kg/ha)	10.00	0.357	0.000	0.275	No trend
		Linseed			
Area (000'ha)	-28.00	-1.000	0.000	<0.0001	Decreasing trend
Prod. (000'tonnes)	-22.00	-0.786	0.000	0.006	Decreasing trend
Productivity (kg/ha)	-20.00	-0.714	0.000	0.014	Decreasing trend

Table 2. Pentad-wise change (%) in area, production, productivity and rainfall in *rabi* oilseed crops

Change during	Area	Production	Productivity	Area	Production	Productivity	Rainfall
	Rapeseed-mustard			Linseed			
2nd pentad over 1st pentad	0.0	-5.6	-3.2	-4.5	10.7	4.1	0.41
3rd pentad over 2nd pentad	22.6	-5.9	-22.3	-12.7	-41.9	-31.6	67.2
4th pentad over 3rd pentad	7.7	-25.0	-34.9	-3.6	-27.8	-24.5	-31.6
5th pentad over 4th pentad	17.1	133.3	103.6	-24.5	15.4	44.8	17.2
6th pentad over 5th pentad	7.3	28.6	21.0	-15.0	-26.7	-14.6	2.4
7th pentad over 6th pentad	3.4	25.0	19.6	-32.4	-45.5	-19.7	-18.4
8th pentad over 7th pentad	0.0	-17.8	-16.6	-39.1	-50.0	-8.5	71.2
8th pentad over 1st pentad	71.7	105.6	20.4	-78.8	-89.3	-51.2	92.6

and technological interventions including improved varieties during the corresponding period which resulted in 105.6% increase in production and 20.4% increase in productivity. The percent shift in area also showed a significant positive correlation with quantum of *rabi* rainfall (r=0.86) which indicated that nearly 74% variation in area sown was due to rainfall variations. Earlier studies on comparative performance of karan rai, an important member of rapeseed-mustard group, indicated that though, the total seasonal rainfall contributed towards the seed yield; yet, about 30% or more if received during flowering to pod formation phase, increased the yields to a larger extent (Prasad and Kumari, 2006).

Linseed

A drastic reduction in area from 6.6 to 1.4 thousand ha was recorded. The production as well as productivity also declined from 1st to 8th pentad (Fig. 3). Pentad-wise per cent shift also indicated a drastic reduction in area by 78.8% thereby the reductions of 89.3% in production and 51.2 percent in productivity were registered during 8th pentad over 1st pentad (Table 2). The shift in linseed area showed a negative and non-significant correlation with seasonal rainfall (r= -0.68) which indicated that nearly 44% variation in area covered was due to rainfall . Studies on changes in the precipitation were also conducted earlier (Mondal *et al.*, 2012 and Rahman and Begum, 2013) but, no such studies have been carried out in the state. However, similar studies were carried out in rapeseed-mustard in Haryana (Singh *et al.*, 2004) and wheat (Kaur *et. al.*, 2006) and rice (Singh *et al.*, 2006) in Punjab on district-wise basis wherein only spatio-temporal trends were studied. The increase in area from 5.3 to 9.1 thousand ha under

rapeseed-mustard and decrease in area from 6.6 to 1.4 thousand ha in linseed during 1968-69 to 2007-08 clearly indicated that the farmers prefer rapeseed-mustard over linseed under rainfed conditions. Dominance Index also exhibited an increase in area over years under rapeseed-mustard while a drastic reduction in linseed spread was observed during past forty years of study (Fig. 4).

Regression analysis: Regression is often used to look for empirical relationship between two variables. In order to model the area and production fluctuations based on rainfall, different linear regression models were fitted both for rapeseed-mustard and linseed with area/production as Y (dependable variable) and rainfall as X (independent variable or predictor) and graphs were auto-generated along with residuals and fit plots. The results indicated an upward slope having positive and non-significant relationship (F=3.83) between rapeseed-mustard area and seasonal rainfall *viz*., if average rainfall increased by 1 mm, average area is predicted to increase by 0.00668 units. Similar trends were also observed with production and rainfall having non-significant F=1.21 which indicated that a significant portion of variation in area and production of rapeseed-mustard was not due to changes in seasonal rainfall (Fig. 5a).

All the residuals exhibited evenly scattered pattern and the average of residuals was zero which showed that the residuals appeared to be fairly normally distributed. Thus, the linear models fitted the data well. In linseed, a significant negative relationship (F=9.52) with downward slope was observed between area and seasonal rainfall viz., if average rainfall increased by 1mm, average area is predicted to decrease by 0.0109 units. Similar trends were observed between production and rainfall with significant F=10.27 indicating that a significant portion of variation in area as well production are explained by variation in seasonal rainfall in linseed (Fig. 5b).

There appears a limited scope to bring additional area under oilseeds as the demand for land to produce other remunerative crops will continue to rise due to population increase. The strategies such as adoption of high yielding, drought tolerant, photo- and thermo-insensitive varieties with multiple resistance, supply of quality seed, use of germplasm resources, adoption of farmers' participatory breeding approach and efficient transfer of various agro-techniques from lab to land are imperative to improve the production and productivity of oilseed crops in the state (Kumari *et al.*, 2006).

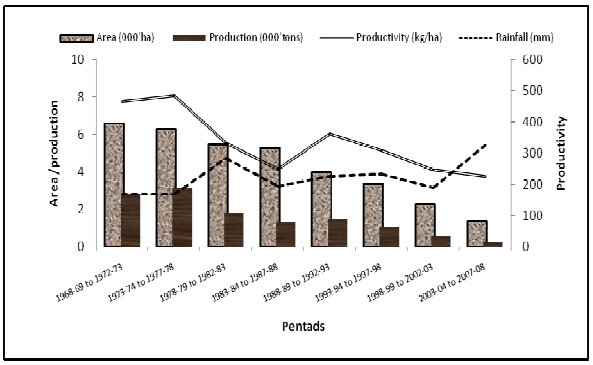

Fig 3. Pentad-wise rainfall, area, production and productivity in linseed

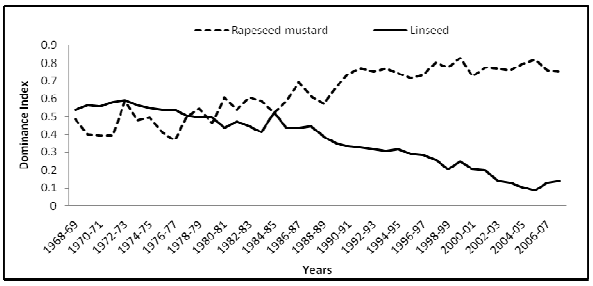

Fig 4. Year-wise Dominance Index in rapeseed-mustard and linseed spread

The findings from the present investigation concluded that the rapeseed-mustard crop showed a significant increase in area, production and productivity while a significant decrease was observed in linseed area, production and productivity from 1968-69 to 2007-08 viz., forty years of study period. Seasonal rainfall recorded 92.6 per cent increase during this period. Per cent shift in rapeseed-mustard area exhibited a significant positive correlation with seasonal rainfall while a non-significant negative correlation was observed between per cent shift in area and seasonal rainfall in linseed. Linear regression analysis indicated that though, the relationship was positive yet, it may not be the sole reason for its area expansion in rapeseed-mustard. On the other hand, both area and production exhibited a significant negative relationship with seasonal rainfall based on regression analysis which suggested that a much part of variation in area as well as production appeared be due to variation in seasonal rainfall in linseed.

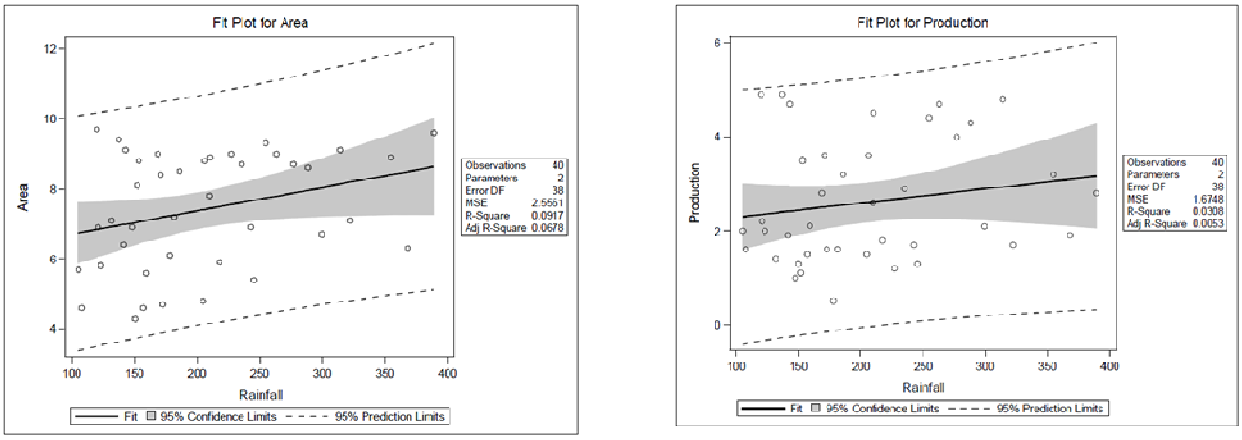

Fig 5a. Fit plots for area and production in rapeseed-mustard

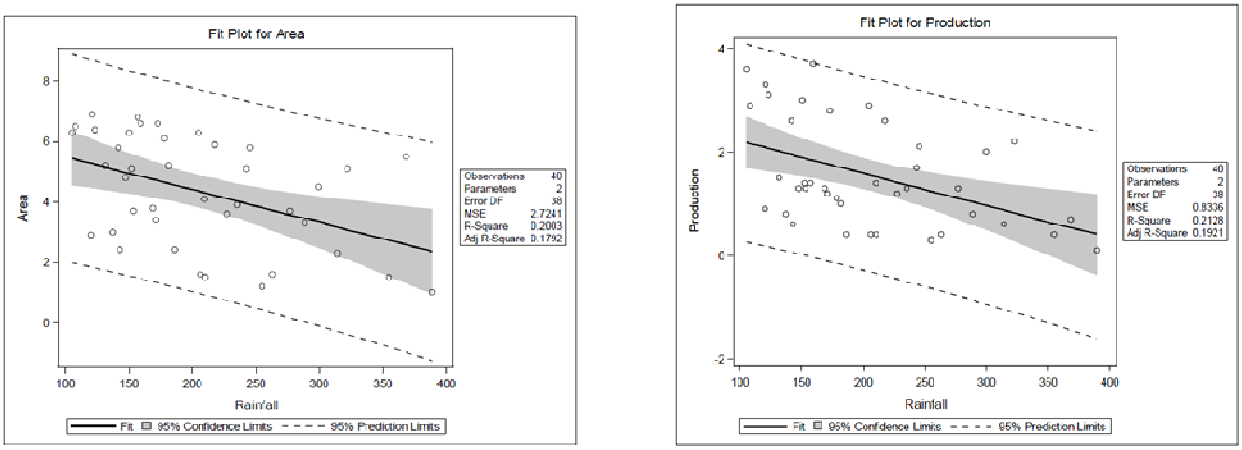

Fig 5b. Fit plots for area and production in linseed

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Impact of National Agricultural Innovation Project on socio-economic status of pashmina goat keepers in Himachal Pradesh

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Abstract

Chegu goats have immense utility in the pastoralist based livestock production system of the area and contribute to the subsistence of small holders. These goats are reared on grazing on common village grazing lands and arid pastures. The pashmina production and productivity has remained static since last so many decades. Therefore, study has been conducted under NAIP on socio economic and production parameters of pasmina goats rearing. The mortality rate of kids born per household from given goats was 27%. The production of wool has increased. About 100% of sample beneficiaries' goat keepers of kids shelters reported that there is improvement in mortality, body weight and safe to kids. The feed blocks and other feed supplements and improved grasses for plantation, etc helps to improve productivity and improvement of health of goats. The opinioned by the majority of the pashmina goat keepers about improved combs were better performance than traditional combs as most of the characters are in favour of improved combs. The per cent goats affected and mortality due to diseases was low due to disease management through drugs and vaccination. The pashmina goat keepers were also educated about goat rearing management practices through awareness camps and trainings. The results of above analysis indicate that the project has succeeded in creating awareness among the pashmina goat keepers about the management practices of pashmina goats rearing and improvement in different production parameters.

Key words: Pashmina production, kids shelters, feed supplements, improved combs, disease care

Livestock constitutes an important means of livelihood in the hill and mountainous region. Among the livestock resources goats represent diversity varying the agro climatic condition of their areas. Among the goats a unique breed of mountain goats called 'Chegu', produce high value special fibre "Pasmina" for woolen textile industry. Chegu goats across the Himalayan ranges, contribute to the subsistence of small holders. The natural habitat of these pashmina- yielding goats extends from the Ladhakh plateau of Jammu & Kashmir through high mountain ranges of Pangi, Lahaul & Spiti and Kinnaur valleys in Himachal Pradesh up to Uttarkashi, Pitthoragarh, and Chamoli districts of Uttarakhand. These areas experience harsh climatic condition characterized by wide temperature variation ranging from -40^{o}C (winter) to 40^{o}C (summer) with low precipitation. The agro climatic conditions of these areas had good adaptability for chegu goats. This region later on developed as the breeding tract for Chegu goats in the state. The Chegu goats have immense utility in the pastoralist based livestock production system of the area. These goats are reared on common village grazing lands and arid pastures with scanty vegetation.

The reliable population estimates of chegu goats are not available. The population of Chegu goats in Himachal Pradesh is less than 0.10 lacs (Thakur *et al*. 2005). The flock size is small (2 to 50) and the production system is non- migrating and mixed farming with other livestock and crop production. The pashmina producing goats farming is the main source of income of economically deprived tribes. Pashmina obtained from chegu goats is a legendry fiber and important component of cultural heritage. Pashmina production is more in males than females due to the difference in body size. There is an apparent variation in the fiber length of Pashmina from different body regions in case of both male

and female. The pashmina production and productivity has remained static since last so many decades, although potential do exists up to 900g (Acharya, and Sharma 1980). Demand for pure and quality pashmina both at national and international level is very high. The local production does not meet the requirement and have to depend on import. Therefore, there is a need to increase the production of Pashmina in the state. So, keeping in view the importance of pashmina a project under National Agricultural Innovation Project (NAIP) was started to enhance the production and productivity of pashmina wool. Under the project education and input material were provided to the goat keepers. The present study focused on to analyze impact on socio-economic and production parameters of pasmina goats rearing.

Materials and Methods

The random sampling technique has been used in the present study for the selection of ultimate sampling units in the districts Lahaul & Spiti and Kinnaur. The information related to chegu goats and kids born, kids weight and their mortality rate have been collected from all the adopters. The impact analysis information on wool production, response of households about kid shelter, feed management, improved combing, drugs & vaccination, etc was collected on sample basis. The sample households comprised of 40 pashmina goat keepers ie. the households adopted under NAIP. The primary data on different parameters of adopted pashmina goat keepers were collected on well-designed pre -tested schedule. The secondary data were collected from various offices of the selected districts. Simple mathematical techniques were followed to analyze the data.

Results and Discussion

The results and discussions are divided into two groups. i) Information collected from secondary sources and ii) Information collected from sample farms.

A *General Description of Study Districts*

The true breeding tract of Chegu goats in Himachal Pradesh is confined to the cold desert region of Spiti (Lahaul & Spiti district) and Hangrang valley (Kinnaur) with pockets of distribution in Todd and Miar valleys across the trans-Himalayan mountain ranges. The entire breeding tract extends over a geographical area of approximately 8,000 sq. km in 80 villages of 2 districts *viz.* Lahaul & Spiti and Kinnaur districts. The native tract of distribution lies between 31°5'N to 32°35' N latitude, 77°2 to 78°45' E longitude and from 3000 to 5000 m altitude.

Human population

The human population of the study districts has been presented in Table 1. Total human population and density of population is very low in these two districts of the state. This may be due to very harsh climatic conditions and difficult terrain. The people of these districts migrate within and outside the state. The sex ratio of these districts was noticed very critical and less than state ratio. The literacy rate was very near to the state literacy rate. These districts has about one per cent of net sown area of the net sown area of the state (Anonymous 2009).

Livestock population

The livestock population plays an important role in the livelihood pattern of the households. The livestock population in Lahaul & Spiti and Kinnaur was 61998 and 126598 (Anonymous 2003) (Table 2) which was 1 and 3% of the state livestock population, respectively.

Table 1. Human population and net sown area in study districts

Particular	Lahaul & spiti	Kinnaur	Himachal Pradesh
Human population (%)	0.55	1.29	100 (60.78)
Population growth rate (1991-2001)	6.17	9.91	17.54
Density per sq km	2.00	12.00	109.00
Literacy rate (%)	75.10	75.20	76.50
Per cent share of female	44.49	46.16	49.19
Sex ratio (Females/thousand males)	1013	857	968
Net sown area (%)	0.56	1.38	100 (540.52)
Total cropped area (%)	0.33	0.92	100 (955.61)

Figure in brackets indicate the total number

Sheep and goats occupies an important place in these districts. The number of vet institutes was 58 and 62, while, in the state this number was 2133. This was about 3% of state institutions in each district.

B *Analysis of different socio-economic parameters of sample households*

Inventory of Chegu goats

Six goats per households were provided in Lahaul, Spiti and Kinnour study area (Table 3). The Mortality rate varied from about 17 in Kinnour to 31% in Lahaul area, which shows slightly high mortality rate. The overall mortality rate was 24%. The high mortality was noted in non-rearing area (Lahaul area). This indicates the need to educate the farmers about management of rearing goats to reduce the mortality rate. It was observed from the Table that kids born per household from given goats were 4.35, 4.40 and 4.35 in Lahaul, Spiti and Kinnour, respectively. The overall mortality rate of kids was 27%. This indicated a slightly high rate of death of the kids. So, sample households were educated about health care and feeding of kids through trainings.

Wool production

Wool production from goats and kids has been presented in Table 4.

Table 2. Livestock population and veterinary Institutes in study districts (no)

Particular	Lahaul & Spiti	Kinnaur	H .P
Cattle	12289	22502	2264160
Buffalo	0	148	760687
Yak	1290	164	1705
Mithun	2	10	14
Sheep	37004	70333	901540
Goats	8443	30325	1240835
Other	2979	3116	42146
Total	61998	126598	5211087
No of vet institute	58 9 (2.72)	62 (2.20)	2133
Animal treated/ vet. institutes	862	1290	1239

Figure in brackets indicate the percentage

Table 3. Information related to Chegu goats (per farm)

Particular	No.of chegu goats distributed			No. of kids borne from given goats		
	Goat	Death	Mortality (%)	Male	Female	Mortality (%)
Lahaul	6.00	1.86	31.00	1.65	1.50	27.58
Spiti	6.00	1.48	24.66	1.71	1.53	26.36
Kinnour	6.00	1.00	16.67	1.60	1.81	27.64
Overall	6.00	1. 46	23.97	1.67	1.63	27.15

Table 4. Production of pashmina wool on sample households (g/unit)

Particular	Goats				Kids			
	2011		2012		2011		2012	
	Wool	SE	Wool	SE	Wool	SE	Wool	SE
Lahaul	184	0.88	194	0.82	22.40	0.88	36.45	0.84
Spiti	194	0.96	202	0.87	20.10	0.90	38.60	0.92
Kinnour	188	1.02	214	0.96	20.46	1.04	34.37	0.96
Overall	189	0.94	203	0.89	21.00	0.95	36.85	0.92

SE = Standard Error

Pasmina wool is harvested annually from March to June. April is reported to be the most appropriate time of wool harvesting by sample households **(**Darokhan & Tomar. 1983**)**. But due to busy in crop farming, the sample households were unable to harvest wool in time. The early wool harvesting was giving better quality wool and productivity. It was noted from the table that production of wool from kids varied from 20.10 to 38.60g in the study area. The small quantity of wool was also obtained by the goat keepers from kids. The productivity of wool per animal was 184g in Lahaul to 214g in Kinnour area. The production of wool of goats and kids was observed higher during 2012 than 2011 in all the study area. On an average there was about 7% increase in wool production in 2012 as compared to 2011.

Similar trend was observed in different study areas. The increase in wool production in 2012 over 2011 may be due to awareness provided to goat keepers by experts during project about the management practices. The production of wool slightly less than potential may be due to high degree of inbreeding, delay and untimely wool harvest, poor management practices followed to rear goats, scanty and poor productivity of grazing lands, inadequate and lack of knowledge of health care of animals. This showed that there is a good potential to increase productivity of wool by educating farmers about the goat rearing management practices. Efforts in this direction have been made in the project to improve these factors.

Shelter management

Shelters of 4 ft x 6 ft were erected in the selected villages (Table 5). Besides these, tarpaulins (15.64 m^2 size) were also given to the selected pashmina goat keepers. It was reported by these pashmina goat keepers that kids mortality was higher before these shelters due to diseases and animals attacks i.e dogs and leopards which has reduced with shelters facility provided during the project. Majority of these farmers were in the opinion that these shelters were safe to kids and improve their body weight. Overall, 74 and 76%, respectively, of the beneficiaries' reported that shelters brought about safety and improvement in body weight of adults as well. In case of kids, 100% respondents believe that shelters reduced risk and increased safety and body weight.

Feed management

The crop by product of peas, potato, barley and local grasses harvested in summer are used by pashmina goats rearers during winter as feed. During summer and rainy season they grazed their goats in pasture lands. The grazing/pasture lands provide different type of plant species to the goats, which help to increase body weight, pashmina wool production and meet their nutritional requirements. It was noted from the Table 6 that majority of the goat keepers before the project used only the crop by products to their animals during winter season. During the NAIP project period the feed supplements were distributed to the adopted goat keepers. Mineral mixture of complete feed blocks and feed was distributed to these goat keepers. It was reported by the goat keepers that minerals blocks and other feed material provided during the project helped to improve goat production and health improvement of animals. These views were supported by 100 per cent of sample farmers. On overall situation, 71 and 72 per cent of sample farmers reported that these feed blocks brought improvement in wool production and improvement in reproductive pattern. These feed supplements are good source of feed especially during scarcity period to meet forage requirement. It was also reported by the respondents that goats not took directly the feed mineral mixture, so they mixed small amount of salt and barley flour and goats relish the mineral mixture. Grazing lands in the study area were degraded and infested with weed growth of bushes and not providing nutritive feed to the animals. So, to improve the pasture lands the seedlings of grasses were distributed during the project period to helps to increase grass lands productivity and provide balance nutritive feed.

Impact analysis of combing

Table 7 gives the comparative views of sample goat keepers about the traditional and improved combs. It was observed from the table that majority (> 80%) of the sample households were of the opinion that introduction of improved combs reduced drudgery, reduced harvest losses, eased removal of wool with uniform fibre length, less guard hair contact, less pressure on wrist, less skin injury, appropriate sharpness etc. compared to traditional combs. It was also noted from the table that improved combs had better performance than traditional combs as most of the characters are in favour of improved combs. Therefore, the improved combs were popularized in the pashmina growing areas.

Impact of drugs & vaccination on mortality rate

Pashmina goats were infested with different types of common intestinal and stomach worms. It was reported that due to reduction in snow fall, threat to disease like PPR (Pestedes petits ruminants), FMD, fever, Diarrhea, etc. have increased. Table 8 shows the response of sample households about the mortality of pashmina goats before and during NAIP. It was noted from the table that mortality due to occurrence of diseases was higher before project.

Table 5. Response (%) of sample pashmina goat keepers about kids shelters

Particular	Mortality before NAIP				Mortality with use of kid shelter			
	Lahaul	Spiti	Kinnour	Overall	Lahaul	Spiti	Kinnour	Overall
Adult								
Higher	91	100	100	96	-	-		
Low	-	-			100	100	100	100
Safe	-	-			76	73	70	74
Improvement of body weight	-	-			72	80	76	76
Young								
Higher	100	100	100	100	-	-		
Low	-	-			100	100	100	100
Safe	-	-			100	100	100	100
Improvement of body weight	-	-			100	100	100	100

Table 6. Impact analysis feed blocks in the study area (%)

Particular	Alternative use before NAIP				Effects of feed blocks given under NAIP			
	Lahaul	Spiti	Kinnour	Overall	Lahaul	Spiti	Kinnour	Overall
Crop by-product	100	100	100	100	100	100	100	100
Scarcity of fodder	100	100	100	100	-	-	-	
Imbalance feed	100	100	100	100	-	-	-	
Health ailments	91	80	90	88	-	-	-	
Feed supplements					100	100	100	100
Improve health					100	100	100	100
Balance feed					100	100	100	100
Improve wool production					72	70	73	71
Improve reproduction					72	70	75	72

During the project implementation, advice through awareness camps and trainings were given to the adopted goat keepers about the disease management. The table revealed that all the respondents in Lahaul and more than 90 per cent in Spiti and Kinnour area reported high mortality rate due to Diarrhea and FMD before the start of the project. The adopter goat keepers of these areas were in view that mortality rate due to diseases given in table has decreased during the project period as reported by more than 80% of sample households. This indicates the impact of drugs and vaccination distributed to the goat keepers and awareness provided during project period.

Marketing and utilization of the pashmina fibre

The organized marketing facilities for pashmina is lacking in the study area. Most of the produce is, therefore utilized locally either in the household or by the local handloom based cottage industry. Due to smaller flock size the pashmina quantity produced by an individual farmer is too small to be marketed directly to the textile industry/wholesaler. Therefore, these goat keepers were not getting reasonable prices for the pashmina wool. So, pashmina wool producers were educated to form co-operative marketing society to manage marketing and processing to earn higher income.

Table 7. Response of sample pashmina goat keepers about improved combing (%)

Comb Character	Lahaul		Spiti		Kinnour		Overall	
	Tradi-tional	Im-proved	Tradi-tional	Im-proved	Tradi-tional	Im-proved	Tradi-tional	Im-proved
Heavy Weight	86		100		100		95	
Light Weight		86		90		90		88
Easiness in handling		100		100		100		100
Sharpness		84		80		84		82
Appropriate width		90		90		88		89
Good performance		100		100		100		100
Easiness in removing inner coat		86		84		82		84
More guard hair content	100		100		100		100	
Less guard hair content		100		100		100		100
More time taken for combing an adult	80		86		90		85	
Less time taken for combing an adult		80		86		90		85
More pressure on wrist	100		100		100		100	
Less pressure on wrist		100		100		100		100
More skin injuries	86		90		86		87	
Less skin injuries		86		90		90		88

Table 8. Response (%) of sample households to introduction of drugs and vaccination on occurrence of diseases of Pashmina goats on sample farms

Diseases	Lahaul		Spiti		Kinnour		Overall	
	Be-fore	NAIP	Before	NAIP	Before	NAIP	Before	NAIP
Diarrhea (Mortality- %)	100	85	94	90	92	90	95	89
Fever/Pneumonia (Mortality- %)	80	60	84	56	80	60	81	58
FMD (Mortality- %)	100	82	94	90	100	80	98	84
PPR (Mortality- %)	92	86	90	80	90	82	91	82

It was concluded from this study that the kid born per household from given goats under NAIP project were 4.52 and their mortality rate was 27%. The production of wool has increased. About 100% of sample beneficiaries' goat keepers of kids shelters reported that there was improvement in survivability, body weight and safety to kids. The feed blocks and other feed supplements and improved grasses for plantation helped to improve goat productivity and improvement of health of goats appreciably. The important benefits of improved combs opinioned by the majority of the pashmina goat keepers were better performance than traditional combs as most of the characters are in favour of improved combs. The per cent goats affected and mortality due to diseases was low due to disease management through drugs and vaccination. The pashmina goat keepers were also educated about goat rearing management practices through awareness camps and trainings. Pashmina wool producers are educated to form co-operative marketing society to manage marketing and processing to earn higher income. The results of above analysis indicated that the project has succeeded in creating awareness among the pashmina goat keepers about the management practices of pashmina goat rearing and improvement in different production parameters.

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Production potential of rice-based cropping sequences on farmers' fields in low hills of Kangra district of Himachal Pradesh

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Abstract

Five rice-based cropping sequences *viz.* rice-wheat, rice - radish - potato, rice - garlic, rice-potato-onion and rice-berseem + oats were evaluated on cultivators' fields for their production potential and economic feasibility in the low hills of Kangra district of Himachal Pradesh. Results revealed that rice-potato-onion, rice - garlic and rice-radish-potato cropping sequences were more remunerative resulting in significantly higher rice equivalent yield (16342, 10997 and 12394 kg/ha/annum, respectively), net returns (INR 153257, 102767 and 106414/ha/annum), productivity and profitability. Rice-potato-onion, rice-radish-potato and rice-garlic cropping sequences resulted in 203.3, 130.1 and 104.1% higher rice equivalent yield over the traditional rice-wheat cropping sequence, respectively. Rice – berseem + oats was also superior to conventional rice - wheat cropping sequence in influencing rice equivalent yield, net returns, B:C and productivity and profitability. In terms of total calories, only rice - potato - onion and rice-radish-potato cropping sequences could excel over the rice-wheat sequence. Conventional rice – wheat cropping system was superior to all the new cropping systems in terms of energy intensity both in physical as well as economic terms. Land use efficiency ranged between 65.7 (rice-radish -potato) and 78.1% (rice-potato-onion) under different cropping systems.

Key words: Production efficiency, economics, yield, rice based cropping sequences

Rice-wheat is the most important cropping system in India (Prasad 2005). It occupies 10.5 m ha productive lands in Indo-Gangetic plains and contributes about 25% of the national food production (Ladha *et al.*, 2000). This system has sustained over years and brings together conflicting and complementary practices. Because of high productivity, stability and less risk, the wide adoption of this system will also play a major role in future planning to sustain self sufficiency of food grains in the years to come (Singh *et al* 2012). But now the productivity of both the crops have stagnated (Yadav 1998) and factor productivity is declining year after year. In Himachal Pradesh, this system covers more than 80 thousand hectares with average productivity of 3.07 t/ha (Anonymous, 2002) as against the national average of 5.70 t/ha (Anonymous, 2003). The farmers realize much of their food security from this cropping system but the low production level needs urgent attention. Besides food security, the low production levels jeopardize farmers' economic security to a considerable extent. To strengthen the economic security, it is imperative to intensify and diversify the existing rice-wheat system with some other crops of greater economic worth. In general, problems with transplanted rice are less than direct seeded rice and wheat. Therefore, it is essential to diversify the system with rice as the base crop with more productive and profitable crops in place of wheat on cultivators' fields on participatory mode.

Materials and Methods

Field investigation to evaluate the production potential of rice-based cropping sequences was undertaken at four centres viz; Fatehpur, Rehan, Jawali and Tripal-Kuthar in district Kangra within NARP Zone I of Himachal Pradesh during 2012-13. In all twelve locations (farmers), three at each centre were selected and considered as replications. Five rice-based cropping sequences *viz.* rice-wheat, rice – radish - potato, rice-garlic, rice-potato-onion and rice-berseem + oats were evaluated. The crops in each cropping sequence were raised in accordance with the recommended package of practices (Table 1).

Table 1. Crop varieties grown and crop wise fertilizer dose

Crop	Variety	Fertilizer dose (kg/ha)		
		N	P_2O_5	K_2O
Rice	Kasturi /HPR 1068	90	40	40
Wheat	HPW-184/HPW 236	120	60	30
Radish	Japanese white	100	50	40
Potato (spring)	Kufri Jyoti	120	80	60
Potato (autumn)	Pukhraj	120	80	60
French bean	Contender	50	80	60
Onion	N-53/AFDR	125	75	60
Berseem + oats	Local	25	60	-
Garlic	Selection-1	125	75	60

Table 2. Soil fertility status of the farmers' fields before sowing of the crops

Centre	pH	OC (%)	Available nutrients (kg/ha)		
			N	P	K
Min	4.9	0.46	243.4	4.5	44.8
Max	6.9	1.09	353.7	44.8	558.7
Average	6.3	0.85	289.6	31.4	320.4
SD	0.5	0.2	36.3	13.8	172.8
CV(%)	8.6	20.2	12.5	44.1	53.9

The soils of the zone were inceptisols having texture varying from loamy sand to silty clay loam, with pH 4.9-6.9 and organic carbon 0.46-1.09%, medium in available N, (289.6 kg/ha), low to high in available P (4.5 kg/ha to 44.8 kg/ha) with mean value of 31.4 kg/ha and low to high in available K with the mean value of 320.4 kg/ha (Table 2) The variation in the content of available K as determined in terms of coefficient of variation (CV%), was large followed by P, OC, N and pH in that order. Total rainfall received during the period was 2203.4 mm with minimum and maximum temperature of the experimental sites varying from 4.0-24.7 ^{0}C and 15.3-36.0 ^{0}C, respectively. Yields were harvested from net plot (Gross plot size, 13.8 m x 7 m). Economics of the crop sequences was computed based upon the prevalent market prices (minimum support price, market price and those fixed by the university). For comparison between crop sequences, the economic yields of crops were converted into rice equivalent on price basis. Area equivalent ratio (AER), relative profit, additional profit and profit equivalent ratio (PER) were determined according to our earlier studies (Rana *et al* 2010) as follows:

AER = Cost of cultivation of conventional cropping sequence/cost of cultivation of alternative cropping sequence

Relative profit (INR/ha) = AER x net returns (INR/ha)

Additional profit (INR/ha) = Relative profit of alternative cropping sequence – net returns of conventional cropping sequence

PER = Relative profit (INR/ha)/ net returns of conventional cropping sequence

Production efficiency (kg/ha/day) was obtained by dividing total production in terms of rice equivalent in a sequence by the total duration of year (365), while production efficiency (INR/ha/day) was obtained by dividing net monetary return by 365.

Energy intensity was worked out as follows:

Energy intensity (physical terms) = energy output/ equivalent yield

Energy intensity (economic terms) = energy output/Cost of cultivation

Homogeneity of error variances was tested by using Bartlett χ^2 – test; which were found to be homogeneous. Therefore, the data were pooled and analyzed in randomized block design.

Results and Discussion

Rice equivalent yield

Rice equivalent yield of the newly introduced cropping sequences *viz.* rice-potato-onion, rice -radish- potato

and rice-garlic was superior to prevalent rice - wheat sequence (Table 3). However, rice-potato-onion cropping sequence was relatively superior in terms of rice equivalent yield (16342 kg/ha/annum). This was followed by rice-radish-potato (12394 kg/ha/annum). The higher rice equivalent yield in these cropping systems was owing to replacement of wheat with high volume/high priced vegetable crops like potato, onion and garlic. Choudhary *et al.* (2001) also reported greater productivity by replacing wheat in rice-wheat system with vegetables like radish and potato under similar agro-climatic conditions. Similarly, a number of findings suggested that inclusion of oilseeds, vegetables, ornamental or fodder crops to diversify the existing rice-wheat system also helped in achieving higher rice equivalent yield (Kumar *et al*. 2008; Sharma *et al*. 2008; Tripathi and Singh, 2008).

The rice – berseem + oats cropping sequence was also superior to rice – wheat in terms of rice equivalent yield. Rice-potato-onion, rice-radish-potato and rice-garlic cropping sequences resulted in 203.3, 130.1 and 104.1%, higher rice equivalent yield over the rice-wheat cropping sequence, respectively.

Net return and B: C ratio

Rice - potato - onion (INR 153257/ha/annum) sequence fetched higher net returns than other cropping sequences (Table 3) due to higher yields. This was followed by rice-radish-potato (INR 106414/ha/annum), rice-garlic (INR 102767/ha/annum) and rice – berseem + oats (INR 100503/ha/annum) with corresponding increase in net returns of 58.3, 52.8 and 49.5%, respectively, over the rice - wheat cropping sequence. Chaudhary *et al* (2001) have also documented higher net income by diversification of the existing rice-wheat cropping system. Rice - berseem + oats gave higher B:C ratio than other cropping sequences. In spite of higher yields and net returns rice - potato – onion, rice - garlic and rice-radish-potato resulted in lower B: C ratio than rice-wheat cropping sequence due to higher cultivation costs incurred under these cropping sequences.

As indicated by the AER (0.367-0.0.516), a farmer cultivating 'rice-wheat' in one ha with cultivation cost of INR 45750, when switches to alternative rice – vegetable ('rice-potato-onion', 'rice-radish-potato' and 'rice - garlic) cropping sequence can cultivate 36.7-51.6% of the area with the same amount (Table 4). Consequently relative profit from these alternative cropping sequences will reduce to 0.367 – 0.516 times of that obtained from one ha. This was 66.7 – 83.8% (i.e. under 'rice-radish-potato' and 'rice – garlic and rice-potato-onion) of what was under rice -wheat. The further analysis indicated that to obtain the same return as under 'rice – wheat', the new cropping systems viz 'rice-potato-onion', 'rice-radish-potato', 'rice – garlic and rice – berseem + oats have to be sown in 43.9, 63.2, 65.4 and 66.9% of the entire area. By switching to cultivation of these alternative copping systems viz. 'rice - potato - onion', 'rice-radish-potato' and 'rice – garlic'), and to get equivalent return as under one ha rice-wheat, a farmer would require INR 8866, 22885 and 12267 more.

Table 3. Crop yield, rice equivalent yield and return under rice based cropping sequences

Sequence	Yield (kg/ha)			Rice equivalent (kg/ha)	Gross return (INR/ha)	Net return (INR//ha)
	Kharif	*Rabi* I	*Rabi* II			
Rice-wheat	2690	3088		5387	112985	67235
Rice-Radish-Potato	2763	13427	11565	12394	215027	106414
Rice-garlic	2736	4428		10997	191444	102767
Rice-Potato-Onion	2784	12442	9391	16342	277749	153257
Rice-Berseem + oats	2764	46974		8545	152620	100503
LSD (P=0.05)				1240	17058	17293

Rice (Basmati) INR15.0-18.0/kg; wheat INR 10.0-11.0/kg; Onion INR 5.00-10.00/kg; Potato INR 4.50-7.00/kg; French bean INR 8.00-20.00/kg; Berseem + Oats (Green fodder) INR 1.20-1.50/kg

Table 4. Economics, productivity (kg/ha/day) and profitability (INR/ha/day) of different crop sequences

Treatment	B:C ratio	COC System (INR/ ha)	AER	Relative profit (INR)	Additional profit	PER	Productivity	Profitability
Rice-wheat	1.47	45750	-				14.8	184.2
Rice-radish-potato	0.98	108613	0.421	44823	-22412	0.667	34.0	291.5
Rice-garlic	1.16	88678	0.516	53019	-14217	0.789	30.1	281.6
Rice-potato-onion	1.23	124492	0.367	56321	-10914	0.838	44.8	419.9
Rice-berseem+oats	1.93	52117	0.878	88225	20990	1.312	23.4	275.4
LSD (P=0.05)							3.4	27.4

However, he can spare 34.5-56.1% of his land resource for some other economic activity.

Production efficiency

All the cropping sequences resulted in higher production efficiency in terms of kg/ha/day (productivity) and INR/ha/day (profitability) over the rice-wheat cropping sequence (Table 4). Rice – potato – onion cropping sequence resulted in the greater productivity (44.8) and profitability (INR 419.9/ha/day) than other cropping sequences. This was followed by rice-radish-potato, rice – garlic and rice – berseem + oats cropping sequences. Productivity (kg REY/ha/day) under rice-potato-onion, rice-radish-potato and rice-garlic was, respectively, 3.0, 2.3 and 2.0 times higher than conventional rice-wheat cropping system. These were 2.1, 1.4 and 1.4 times, respectively, higher in profitability over the rice - wheat system.

The productivity and profitability scenario clearly depicted that there was sufficient availability of food and cash for an average marginal family having one ha of land.

Total calories of the main product

Rice - potato – onion and rice-radish-potato were excelled over the rice-wheat sequence in terms of the production of total calories of the main products (Table 5). Total calories under these cropping systems were 27.4 and 15.4%, respectively, higher than that observed under the rice-wheat system. This indicated that these systems had higher amount of high quality produce. Sharma *et al*. (2008) also documented higher energy output of cropping sequences in which potato crop was included. In spite of significant increase in rice equivalent yield, total calories under rice garlic and rice – berseem + oats sequences, were 53.8 and 87.7%, respectively, of rice - wheat sequence.

Table 5. Total calories of the main product and energy intensity under different cropping systems.

Cropping sequence	Total calories (10^6 K cal/ha)				Energy intensity	
	Kharif	*Rabi* I	*Rabi* II	Total	Physical terms (k cal/kg)	Economic (k cal/INR)
Rice-wheat	9.2	10.7		19.9	3695.9	435.2
Rice-radish-potato	9.5	2.3	11.2	23.0	1854.0	211.6
Rice-garlic	9.4	1.3		10.7	974.2	120.8
Rice-potato-onion	9.5	12.1	3.8	25.4	1552.7	203.8
Rice-berseem+oats	9.5	8.0		17.5	2044.0	335.1
LSD (P=0.05)				1.1		

It is pertinent to mention that in spite of higher total energy output of the main product, all the new cropping systems were inferior to the conventional rice – wheat cropping system in terms of energy intensity both in physical as well as economic terms (Table 5).

Thus, it is concluded that farmers of low hills of HP can adopt rice - potato – onion, rice – radish - potato and rice – garlic cropping sequences for higher net income as an alternative to rice-wheat cropping system. However, complete replacement is not advisable.

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Economics of post-emergence weed control in garden pea (*Pisum sativum* L.) under mid hill condition of Himachal Pradesh

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Abstract

A field experiment consisting of twelve treatments [*viz*. pendimethalin 1500 g/ha (pre-emergence, pre), pendimethalin 1000/ imazethapyr 100 g/ha (pre) followed by (fb) imazethapyr 100 g/ha post-emergence (post), imazethapyr + pendimethalin (Vellore) 1200 and 1500 g/ha (pre), imazethapyr + pendimethalin 1000 g/ha (pre) fb imazethapyr 100 g/ha (post), imazethapyr + imazamox (Odissy) 60 and 90 g/ha (post), pendimethalin 1000 g/ha fb imazethapyr + imazamox 60 g/ha (post), pendimethalin 1000 g/ha fb hand weeding (45 DAS), weed free and weedy check] was carried out during the winter season of 2012-13 and 2013-14 on a silty clay loam soil at Palampur to study the impact of post-emergence (post) weed control in pea. Weed free, pendimethalin fb hand weeding, pendimethalin fb imazethapyr + imazamox, imazethapyr + pendimethalin fb imazethapyr and imazethapyr + imazamox 60 g/ha gave more than 85% weed control efficiency upto 60 DAS. Weed free, pendimethalin 1000 g/ha *fb* HW **(**45 DAS) and pendimethalin 1000 g/ha *fb* imazethapyr + imazamox 60 g/ha (45 DAS) gave significantly higher green pod yield. Imazethapyr 100 g/ha *fb* imazethapyr 100 g/ha (45 DAS) had minimum weed persistence index (WPI). Crop resistance index (CRI) was highest under pendimethalin 1000 g/ha *fb* HW (45 DAS) followed by pendimethalin 1000 g/ha *fb* imazethapyr + imazamox 60 g/ha (45 DAS). Application of pendimethalin 1000 g/ha *fb* HW (45 DAS) followed by pendimethalin 1000 g/ha *fb* imazethapyr + imazamox 60 g/ha (45 DAS) resulted in higher net returns. Marginal benefit cost ratio (MBCR) was highest under imazethapyr + imazamox 60 g/ha (25.28).

Key words: Garden pea, imazethapyr, imazamox, pendimethalin, impact assessment

Himachal Pradesh has rich biodiversity and varied agro-climatic conditions which are highly suitable for growing peas round the year. In the recent past garden pea for its green pod has gained popularity among farming community. Pea has great potential for grain as well as vegetable purposes. As vegetable, it is grown in almost all agro-climatic zones of Himachal Pradesh. The green pods from hills are available at a time (April – October), when it cannot be grown in the plains due to high temperature. As a sequel of the fact, the produce is sold at a higher premium bringing lucrative returns to the growers (Sangar 2003). Wider spacing in peas provides ample opportunities for weed infestation resulting in 18-76% yield losses (Singh *et al*., 1991; Kundra *et al.*, 1993; Banga *et al.*, 1998).

Hence effective weed management is pre-requisite to reduce losses caused by weeds and thereby improving productivity and profitability. Hand weeding is a commonly adopted method of weed control by farmers in field pea. This method is not only costly but also time consuming.

Chemical method of weed control is an effective and economical as compared to mechanical method. The pre-emergence application of herbicides is more common in pea. However, the major limitation with the use of pre-emergence application is the requirement of optimum moisture in the soil for its activity either through rainfall or irrigation water. High rainfall however can move a concentrated band of herbicide from the soil surface to the root zone and may result in crop injury. The post-emergence herbicides may be effective under these conditions. The post emergence herbicides have more flexible window of application and can be applied according to the types and density of weeds present. Mishra (2006) reported the effective control of wild oat with the post

-emergence herbicides in field pea. Imazethapyr and pendimethalin have been reported to be the effective chemical treatments for weed control in pea (Rana et al. 2013). New post-emergence herbicides *viz.*, imazethapyr alone and in combination with imazamox (odissey) have been introduced. The present investigation was carried out to study the impacts of post emergence weed control in pea under mid hill conditions of Himachal Pradesh.

Materials and Methods

The field experiment was conducted during *rabi* 2012 -13 and 2013-14 at Palampur. The soil of the experimental field was silty clay loam in texture, acidic in reaction (pH 6.0) and medium in available N (322.9 kg/ha) and K (276.4 kg/ha) and high in available P (25.8 kg/ha). Twelve treatments viz. pendimethalin 1500 g/ha (pre), pendimethalin 1000 g/ha (pre) *fb* imazethapyr 100 g/ha (45 DAS), imazethapyr 100 g/ha (pre) *fb* imazethapyr 100 g/ha (45 DAS), imazethapyr + pendimethalin 1200 & 1500 g/ha (pre), imazethapyr + pendimethalin 1000 g/ha (pre) *fb* imazethapyr 100 g/ha (45 DAS), imazethapyr + imazamox 60 & 90 g/ha (45DAS), pendimethalin 1000 g/ha (pre) *fb* imazethapyr + imazamox 60 g/ha (45 DAS), pendimethalin 1000 g/ha (pre) *fb* HW (45 DAS), weed free and weedy check were evaluated in randomized block design with three replications. Sowing of pea variety 'Palam Priya' was done during the last week of October on raised beds using 60 kg/ha seed rate in a row to row spacing of 45 cm. Application of herbicides was made with power sprayer using 750 L water per hectare. Except weed control treatments, the crop was raised in accordance with the recommended package of practices. The crop was fertilized with 45 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha as basal dose.

Weed count was recorded at 60 DAS, 90 DAS, 120 DAS and at harvest from two randomly selected spots (0.5 m^2) in each plot and expressed as number/m^2. The data on count were subjected to square root transformation. Yields were harvested from net plot (3.1 m x 2.7 m). Impact assessment indices were worked out as per Walia (2003).

Weed persistence index (WPI)

$$WPI = \frac{\text{Weed weight in treated plot}}{\text{Weed weight in control plot}} \times \frac{\text{Weed count in control plot}}{\text{Weed count in treated plot}}$$

Crop resistance index (CRI)

$$CRI = \frac{\text{Crop weight in treated plot}}{\text{Crop weight in control plot}} \times \frac{\text{Weed weight in control plot}}{\text{Weed weight in treated plot}}$$

Pest (weed) management index (PMI or WMI)

$$PMI = \frac{\text{Percent yield over control}}{\text{Percent control of the pest}}$$

Agronomic management index (AMI)

$$AMI = \frac{\text{Percent yield over control} - \text{Percent control of the pest}}{\text{Percent control of the pest (weed)}}$$

Integrated Management index (IPMI)

$$IPMI = \frac{PMI + AMI}{2}$$

Treatment (Herbicide) efficiency index (TEI)

$$TEI = \frac{\frac{\text{Yield of treatment} - \text{Yield of control}}{\text{Yield of control}} \times 100}{\frac{\text{Weed weight in treatment}}{\text{Weed weight in control}} \times 100}$$

HEI indicates the weed killing potential of a herbicide treatment and its phytotoxicity on the crop.

Economics of the treatments was computed based on the prevalent market prices of the inputs used and output produced.

Results and Discussion

Weed count

The weed flora of the experimental field was mainly composed of *Phalaris minor*, *Alopecurus myosuroides*, *Avena ludoviciana*, *Lolium temulentum* and *Vicia sativa*. There was also a little infestation of *Stellaria media*, *Poa annua*, *Anagallis arvensis* and *Coronopus didymus.*

Weed control treatments brought about significant variation in total weed control at all the stages of observation (Table 1.). All weed control treatments were significantly superior to weedy check in reducing the density of weeds at all the stages of observation. Weed density was significantly lower under weed free, pendimethalin 1000 g/ha *fb* HW (45 DAS), pendimethalin 1000 g/ha *fb* imazethapyr + imazamox 60 g/ha (45 DAS) over other herbicide combinations. The activity of pendimethalin *fb* HW (Vaishya *et al.* 1999; Prakash *et al.* 2000; Rana 2002) and imazethapyr (Zabara and Yankovskaya 2007) against weeds in pea has been established. Due to synergetic, enhancement or additive effects, herbicidal combinations in general were better than sole application of herbicides in reducing the population of weeds.

Weed control efficiency (WCE) ranged from 40.6% under imazethapyr 100 g/ha (pre) *fb* imazethapyr 100 g/ha (45 DAS) to 87.9% under pendimethalin 1000 g/ha (pre) *fb* 1HW at maximum weed count (90 DAS). Until 60 DAS, weed free, pendimethalin fb hand weeding, pendimethalin fb imazethapyr + imazethamox, imezethapyr + pendimethalin fb imazethapyr and imazethapyr + imazamox 60 g/ha were the effective treatments gave more than 85% weed control efficiency. The other treatments had lower weed control efficiency and thus were not satisfactory.

Impact assessment

Weed free, pendimethalin 1000 g/ha *fb* HW **(**45 DAS) and pendimethalin 1000 g/ha *fb* imazethapyr + imazamox 60 g/ha (45 DAS) gave significantly higher green pod yield (Table 2). Imazethapyr + imazamox 90 g/ha (45 DAS) and imazethapyr + pendimethalin 1000 g/ha *fb* imazethapyr 100 g/ha (45 DAS) being statistically similar were the other superior treatments in influencing green pod yield. Weeds in weedy check reduced the green pod yield of pea by 36.6% over pendimethalin 1000 g/ha *fb* imazethapyr + imazamox 60 g/ha (45 DAS). Imazethapyr 100 g/ha *fb* imazethapyr 100 g/ha (45 DAS) had minimum weed persistence index (WPI) probably owing to more persistence and broader activity spectrum of the chemical. It was followed by pendimethalin 1000 g/ha *fb* imazethapyr 100 g/ha (45 DAS), pendimethalin 1500 g/ha (pre) and imazethapyr + pendimethalin 1500 g/ha (pre). Crop resistance index (CRI) was highest under pendimethalin 1000 g/ha *fb* HW (45 DAS). It was followed by pendimethalin 1000 g/ha *fb* imazethapyr + imazamox 60 g/ha (45 DAS) and imazethapyr + imazamox 60 g/ha (45 DAS). Agronomic management index (AMI) and weed management index (WMI) were lowest under weed free followed by pendimethalin 1000 g/ha *fb* HW (45 DAS), imazethapyr + imazamox 60 g/ha (45 DAS), pendimethalin 1000 g/ha *fb* imazethapyr + imazamox 60 g/ha (45 DAS) and imazethapyr + pendimethalin 1200 g/ha (pre).

Economics

Owing to higher seed yield, weed free resulted in highest gross return and gross return due to weed control (Table 3.). It was followed by pendimethalin 1000 g/ha *fb* HW (45 DAS) and pendimethalin 1000 g/ha *fb* imazethapyr + imazamox 60 g/ha (45 DAS). Weed free was a costly practice while pendimethalin 1500 g/ha (pre) the costliest herbicide followed by imazethapyr + imazamox 60 g/ha (45 DAS).

Table 1. Effect of treatments on total weed count (No./m^2) and weed control efficiency

Treatment	Dose (g/ha)	Time of application	Weed count (DAS)				Weed control efficiency (DAS)			
			60	90	120	At harvest	60	90	120	At harvest
Pendimethalin	1500	Pre emergence	13.7 (186.7)	18.2 (329.6)	15.5 (240.0)	10.6 (112.0)	65.3	42.7	52.8	71.0
Pendimethalin *fb* imazethapyr	1000 *fb* 100	Pre *fb* post (45 DAS)	12.9 (165.3)	15.8 (250.7)	14.3 (202.7)	9.5 (90.7)	69.3	56.4	60.2	76.5
Imazethapyr *fb* imazethapyr	100 *fb* 100	Pre *fb* post (45 DAS)	13.1 (170.7)	18.5 (341.3)	16.5 (272.0)	13.7 (186.7)	68.3	40.6	46.5	51.6
Imazethapyr + pendimethalin	1200	Pre emergence	10.4 (106.3)	14.6 (213.3)	14.0 (196.3)	10.4 (106.7)	80.2	62.9	61.4	72.3
Imazethapyr + pendimethalin	1500	Pre emergence	10.1 (101.3)	13.7 (186.7)	13.1 (170.7)	10.8 (117.3)	81.2	67.5	66.5	69.6
Imazethapyr + pendimethalin *fb* imazethapyr	1000 *fb* 100	Pre *fb* post (45 DAS)	7.0 (48.0)	12.0 (144.0)	11.3 (127.5)	7.4 (53.3)	91.1	75.0	74.9	86.2
Imazethapyr + imazamox	60	Post (45 DAS)	8.0 (64.0)	12.7 (160.0)	11.8 (137.6)	8.3 (69.3)	88.1	72.2	73.0	82.0
Imazethapyr + imazamox	90	Post (45 DAS)	9.8 (96.0)	13.9 (192.0)	12.5 (154.7)	9.5 (90.1)	82.2	66.6	69.6	76.6
Pendimethalin *fb* imazethapyr + imazamox	1000 *fb* 60	Pre *fb* post (45 DAS)	3.6 (16.0)	10.1 (101.3)	8.3 (69.3)	6.2 (37.3)	97.0	82.4	86.4	90.3
Pendimethalin *fb* HW	1000	Pre *fb* HW (45 DAS)	2.0 (5.3)	8.4 (69.3)	7.7 (58.7)	5.2 (26.7)	99.0	87.9	88.5	93.1
Weed free	-	-	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	100.0	100.0	100.0	100.0
Weedy check	-	-	23.2 (538.7)	24.0 (574.9)	22.6 (508.8)	19.7 (385.6)	0.0	0.0	0.0	0.0
SE(m±)			0.89	0.58	0.57	0.62				
CD (P=0.05)			1.9	1.2	1.2	1.3				

The data on weed count have been transformed to square root transformation. Value given in parentheses are the means of original values.

Table 2. Effect of weed control treatments on yield and impact indices in pea

Treatment	Dose (g/ha)	Time of application	Pod yield (t/ha)		WPI	CRI	WMI	AMI	IWMI	HEI
Pendimethalin	1500	Pre	6.57	6.57	0.90	2.62	2.96	1.96	2.46	0.87
Pendimethalin *fb* imazethapyr	1000 *fb* 100	Pre *fb* post	6.29	6.49	0.88	3.39	2.31	1.31	1.81	1.05
Imazethapyr *fb* imazethapyr	100 *fb* 100	Pre *fb* post	6.21	6.37	0.87	2.47	2.89	1.89	2.39	0.74
Imazethapyr + pendimethalin	1200	Pre	5.97	6.25	0.96	3.59	2.09	1.09	1.59	0.98
Imazethapyr + pendimethalin	1500	Pre	6.13	6.41	1.41	2.83	2.55	1.55	2.05	0.83
Imazethapyr + pendimethalin *fb* imazethapyr	1000 *fb* 100	Pre *fb* post	6.09	6.81	1.41	3.81	2.19	1.19	1.69	1.20
Imazethapyr + imazamox	60	Post	6.01	6.69	1.20	4.06	2.07	1.07	1.57	1.23
Imazethapyr + imazamox	90	Post	6.53	6.81	1.13	3.76	2.32	1.32	1.82	1.28
Pendimethalin *fb* imazethapyr + imazamox	1000 *fb* 60	Pre *fb* post	7.01	7.25	1.43	5.98	2.08	1.08	1.58	2.33
Pendimethalin *fb* HW	1000	Pre *fb* HW	7.17	7.33	1.93	6.60	2.06	1.06	1.56	2.64
Weed free	-	-	7.21	7.37	-	-	1.61	0.61	1.11	-
Weedy check	-	-	4.34	4.74	1.00	-	-	-	-	0.00
SE(m±)			0.26	0.43	-	-	-	-	-	-
LSD (P=0.05)			0.56	0.90	-	-	-	-	-	-

WPI- Weed persistence index, CRI- Crop resistance index, WMI- Weed management index, AMI- Agronomic management index, IWMI- Integrated Weed management index, HEI- Herbicide efficiency index

Table 3. Economics of weed control treatments

Treatment	Dose (g/ha)	Time of application	GR	GRwc	CWC	NRwc	MBCR
Pendimethalin	1500	Pre emergence	134926	36718	1425	35293	24.77
Pendimethalin *fb* imazethapyr	1000 *fb* 100	Pre *fb* post (45 DAS)	133572	35364	2050	33314	16.25
Imazethapyr *fb* imazethapyr	100 *fb* 100	Pre *fb* post (45 DAS)	130864	32656	1720	30936	17.99
Imazethapyr + pendimethalin	1200	Pre emergence	128714	30506	1560	28946	18.55
Imazethapyr + pendimethalin	1500	Pre emergence	131820	33612	1770	31842	17.99
Imazethapyr + pendimethalin *fb* imazethapyr	1000 *fb* 100	Pre *fb* post (45 DAS)	140183	41975	2280	39695	17.41
Imazethapyr + imazamox	60	Post (45 DAS)	137634	39427	1500	37927	25.28
Imazethapyr + imazamox	90	Post (45 DAS)	140104	41896	1890	40006	21.17
Pendimethalin *fb* imazethapyr + imazamox	1000 *fb* 60	Pre *fb* post (45 DAS)	149104	50896	2690	48206	17.92
Pendimethalin *fb* HW	1000	Pre *fb* HW (45 DAS)	150777	52569	5950	46619	7.84
Weed free	-	-	151573	53365	11900	41465	3.48
Weedy check	-	-	98208	0	0	0	

GR, gross return (INR/ha); GR_{WC}, gross return due to weed control (INR/ha); CWC, cost of weed control (INR/ha); NR_{WC}, net return due to weed control (INR/ha); MBCR, Marginal benefit cost ratio

Maximum cost of weed control was under weed free treatment because of use of more workers. The cost variation has changed the trends in net return. Net returns accrued under different treatments followed almost the same trend as gross returns. Net returns from weed free treatment was lower as compared to other weed control treatments due to higher cost. Application of pendimethalin 1000 g/ha *fb* HW (45 DAS) resulted in higher net returns. This was followed by pendimethalin 1000 g/ha *fb* imazethapyr + imazamox 60 g/ha (45 DAS). Weed control treatments were superior to weedy check in influencing net returns due to weed control. Similar results were reported by Rana (2002). He also obtained higher net returns with better control of weeds. Due to lower cost of treatment, imazethapyr + imazamox 60 g/ha (25.28) resulted in the highest marginal benefit cost ratio (MBCR) closely followed by pendimethalin 1500 g/ha (24.77) and imazethapyr + imazamox 90 g/ha (21.17). Due to higher cost in manual weeding, weed free gave lowest MBCR (3.48). In the weed free, MBCR was 86.2% of the imazethapyr + imazamox 60 g/ha.

The findings of present investigation conclusively inferred that pendimethalin 1000 g/ha (pre) fb hand weeding and pendimethalin 1000 g/ha (pre) fb imazethapyr + imazamox 60 g/ha (post) were the better alternatives to get higher net returns.

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Studies on preparation and evaluation of value added products from *Giloy (Tinospora cordifolia)*

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Abstract

Giloy is rich in nutritional and therapeutic values. It is consumed by the people in the form of decoction to cure certain ailments. The plant is well known for its phyto-chemical constituents. There was an urgent need for recognition of medicinal properties of *giloy* and to prepare certain value added products. Results of the study revealed that *Giloy* contains good amount of crude fibre (5.72) and ash content (6.35%). It is also rich in various minerals, especially calcium and iron (9.41 and 0.29 mg/100g, respectively). An attempt has been made to utilize *giloy* stem samples for the preparation of value added products viz. RTS, squash and syrup. The prepared products were assessed for chemical, nutritional and sensory parameters. All the beverages prepared from *Giloy* were acceptable. The blending of kinnow further improved the sensory quality as well. In the present scenario, where lot of emphasis is being laid on the consumption of healthy food, development of such products might help the consumers to harness the nutritional and medicinal properties of such unexploited locally available herb.

Key words: *Giloy*, *Kinnow*, RTS, squash, syrup, chemical evaluation, nutritional evaluation, sensory evaluation

Since the past decade, the therapeutic use of herbal medicine is gaining considerable momentum in the world. Due to toxicity and side effects of allopathic medicines, there is an increased rely on use of herbal medicines. Approximately, 80% of the population of our country use traditional medicines for their primary health care. So there is a great need for the recognition of the medicinal and economic benefits of flora and fauna grown in the lap of Himalayas.

Tinospora cordifolia (*Menispermaceae*) commonly known as *Giloy*, a Hindu mythological term is refers to the heavenly Elixir. *Giloy* is used in the traditional medicinal system since ages. Its stem and roots are used as herbal remedies. The plant is a large, glabrous, deciduous climbing shrub and distributed throughout subtropical and tropical Indian sub-continent, extending from the Himalayas down to the southern part of Peninsular India. The stem is bitter in taste and stimulates bile secretion, stomachic, diuretic and cures jaundice. It is a best remedy for children suffering from upper respiratory tract infections (Vedavathy and Rao 1991). The crude extract of dry stem of *Tinospora cordifolia* enhanced immune responses (Manjrekar et al. 2000). The extract of *cordifolia* has an anti- hyperglycemic property (Rajalakshmi et al. 2009).

It might increase the leucocytes and phagocytic cells (Dikshit et al. 2000). Traditionally people consume it in the crude form as a remedial measure in certain ailments. No work has been reported on the estimation of quality attributes and product development of *Giloy*. So, keeping in view its therapeutic as well as nutritional values, the present study was envisaged with the objective of the development and evaluation of value added product by using its stems.

Materials and Methods

The present investigation was conducted at Palampur with the raw material procured locally. The stems were cleaned, washed properly to remove any dust and debris. The juice was extracted as explained in Fig 1.

Development of Beverages (RTS, Squash, Syrups) by using *Giloy* stems

Preliminary work was done to standardize the recipe for beverages by using various blends of juices (*Giloy* and Kinnow). The prepared samples were offered to judges to know best level of proportion of fruits with plant juices. The treatments were 100% G (*Giloy*) [T_0], 75 G:25 K (*Kinnow*) [T_1], 50 G:50 K (*Kinnow*)[T_2], 25 G:75 K (*Kinnow*) [T_3] and 100% K (*Kinnow*)[T_4]. The stored juice was used for the preparation of value added products as per FSSAI specification.

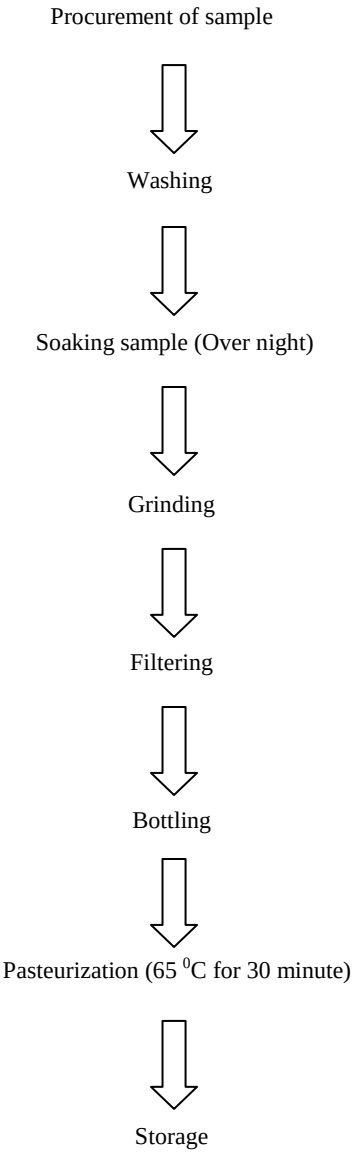

Fig 1. Unit operations for the extraction of juice

The prepared samples were evaluated for physical, chemical, nutritional and organoleptic evaluation by using standard techniques.

Physical evaluation

The colour and shape of the samples were observed from their physical appearance through visual perception. Whereas weight was recorded by taking ten cut pieces of equal sized stem of *Giloy* in triplicate on an electrical weighing balance. The length was measured by using ten cut pieces of equal sized stem of *Giloy* in triplicate. The circumference was measured by taking ten cut pieces of equal sized stem of *Giloy* in triplicate. Diameter was measured with the help of a vernier caliper and circumference was obtained by dividing the diameter by two.

Chemical and nutritional evaluation

The proximate composition was done by using standard methods prescribed by AOAC (1990). ADF and NDF were estimated by the methods of Soest and Wine (1967). The various nutritional parameters viz. pH, TSS, acidity, ascorbic acid, minerals and sugars were estimated by following the methods given by Rangana (1995).

Organoleptic evaluation

The organoleptic evaluation was done as per the method suggested by Gould (1978). The sensory attributes like colour, flavour, taste, consistency and overall acceptability of the products were evaluated. A minimum of 10 judges were selected at random to record their preference and acceptability of the products on the evaluation sheets.

Results and Discussion

Physical evaluation

Giloy stem was evaluated physically in terms of colour, shape, weight and circumference. The colour of the *Giloy* stem was light brown. Shape of the test species delineated in the Plate 1 was found to be cylindrical. The Table 1 shows the mean length 4.50 cm of the *Giloy* stem cut pieces weighing 1.71 g. The circumference of *Giloy* stem was established as 0.40. Raoof and Siddiqui (2012) reported the sample length 8.32±0.13 cm in *Giloy* stem. However, varietal differences, agro climatic conditions, maturity and the time of the harvesting might have made variation.

Sample	*Giloy*
Length (cm)	4.50
Weight (g)	1.71
Circumference (cm)	0.40
Color	Light brown
Shape	Cylindrical

Chemical evaluation

Moisture (%), protein and fat contents in *Giloy* stems were observed as 10.63, 2.13 and 1.92, respectively (Table 2). Ash gave insight of the mineral composition which came out to be 6.35%. The crude fibre was 5.72%. NDF and ADF were 24.80 and 33.80%, respectively. Nile and Khobragade (2009) have reported the values for ash

a. Shrub

b. Fresh stem

c. Dry stem

A. Powder

Plate 1. Physical appearance of *Giloy*

(12.40%), moisture (18.34%), crude fat (3.10%), crude protein (4.50%) and crude fibre (15.90%) of *Giloy* stem as closer as our values. A slight variation in some of the parameters might be due to the varietal differences, agro climatic conditions, maturity and the time of the harvesting.

Table 2. Proximate composition of *Giloy*

Parameters	*Giloy* (%)
Moisture Content	10.63
Protein	2.13
Fat	1.92
Ash	6.35
Crude Fibre	5.72
NDF	24.80
ADF	25.20

Each value representing the mean of three values

Nutritional evaluation of freshly prepared *Giloy: Kinnow* based RTS

An effort was made to prepare the *Giloy* RTS *(Ready to serve)* blended with the kinnow not only to improve the taste but also to improve the appearance and nutritional value. A critical visualization of data in Table 3 revealed that TSS of Giloy based RTS ranged from 13.99 to 14.71 ^{o}Brix. The values of the total solids were observed as 13.99, 14.50, 13.53, 14.31, 14.71 for T_o, T_1, T_2, T_3, T_4, respectively.

The pH values for the RTS beverage under T_o, T_1, T_2, T_3, T_4 were 5.63, 5.71, 4.68, 3.56 and 2.24, respectively. The per cent values for acidity were 0.26, 0.41, 0.68, 0.99, 1.45 in T_1, T_2, T_3, T_4, and T_5, respectively. The ascorbic acid value ranged from 3.50 to 3.82 mg/100g. The values for the per cent total sugars were recorded as 9.30, 9.28, 9.10, 9.18 and 4.78, for reducing sugars 2.95, 2.90, 2.86, 2.83 and 1.90% and for non-reducing sugars, 6.680, 6.71, 6.56, 6.84 and 3.03% under T_o, T_1, T_2, T_3 and T_4, respectively.

Organoleptic evaluation of freshly prepared *Giloy: Kinnow based* RTS

The prepared products were also evaluated organoleptically. The products were offered to a panel of judges and according to their preference sensory parameters are depicted in Table 4. The score for colour of RTS were recorded to be as 7.38, 7.30, 7.14, 7.65, 8.16 for treatments T_o, T_1, T_2, T_3, T_4, respectively. The scores for flavour were ranged from 6.25 to 7.54 for T_o and T_4, respectively. The scores for the taste of RTS were 7.93 for T_4 most accepted, 7.16 for T_2 intermediate and 5.02 for T_o the lowest accepted treatment.

The treatment T_4 was most preferred (8.09) by the judges followed by the T_3 (7.72) and T_2 (7.32) for the overall acceptability. The scores for the consistency were ranged from 8.06 to 8.73 for all the five treatments. Bharmoria (2011) confirms the present finding for fresh samples analysis of *Giloy beverages.*

Nutritional evaluation of freshly prepared *Giloy: Kinnow* based squash

Table 5 represents the values for total soluble solids in ^{o}Brix for syrup. It is clear that the values of the total soluble solids were observed to be 44.90, 44.91, 44.55, 44.05, 45.00 ^{o}Brix for T_o, T_1, T_2, T_3, T_4., respectively. The pH value for the squash beverage was 5.66, 5.76, 4.72, 3.60, and 2.28 for T_o, T_1, T_2, T_3 and T_4, respectively. The acidity per cent value for T_o, T_1, T_2, T_3, T_4., were observed as 0.31,

Table 3. Nutritional parameters of freshly prepared *Giloy: Kinnow* based RTS

Parameters	Treatment				
	T_0	T_1	T_2	T_3	T_4
TSS (^{0}Brix)	13.99	14.50	13.53	14.31	14.71
pH	5.63	5.71	4.68	3.56	2.24
Acidity (%)	0.26	0.41	0.68	0.99	1.45
Ascorbic acid (mg/100g)	3.82	3.79	3.50	3.80	3.78
Total sugars (%)	9.30	9.28	9.10	9.18	4.78
Reducing sugars (%)	2.95	2.90	2.86	2.83	1.90
Non-reducing sugars (%)	6.68	6.71	6.56	6.84	3.03

Each value representing the mean of three values

Table 4. Sensory scores of freshly prepared *Giloy: Kinnow* based RTS

Parameters	Treatment				
	T_0	T_1	T_2	T_3	T_4
Color	7.38	7.30	7.14	7.65	8.16
Flavour	6.25	6.67	6.82	7.27	7.54
Taste	5.02	6.21	7.16	7.61	7.93
Consistency	8.06	8.02	8.14	8.36	8.73
Over all acceptability	6.68	7.05	7.32	7.72	8.09

Each value representing the mean of three values

Table 5. Nutritional parameters of freshly prepared *Giloy: Kinnow* based squash

Parameters	Treatment				
	T_0	T_1	T_2	T_3	T_4
TSS (^{0}Brix)	44.90	44.91	44.55	44.05	45.00
pH	5.66	5.76	4.72	3.60	2.28
Acidity (%)	0.31	0.46	0.72	1.06	1.50
Ascorbic acid (mg/100g)	2.49	3.83	4.51	5.45	8.96
Total sugars (%)	31.58	31.39	30.08	31.36	31.00
Reducing sugars (%)	11.11	11.01	10.95	11.05	11.07
Non-reducing sugars (%)	21.54	21.48	20.13	21.37	20.97

Each value representing the mean of three values

0.46, 0.72, 1.06, and 1.50, respectively. The ascorbic acid value for treatments T_o, T_1, T_2, T_3, T_4., was 2.49, 3.83, 4.51, 5.45, 8.96 mg/100 g, respectively. The value for total sugars was 31.58, 31.39, 30.08, 31.36, 31.00%; reducing sugars 11.11, 11.01, 10.95, 11.05, 11.07% and non-reducing sugar as 21.54, 21.48, 20.13, 21.37, 20.97 for T_o, T_1, T_2, T_3, T_4, respectively.

Organoleptic evaluation of freshly prepared *Giloy: Kinnow* based squash

The prepared products were also evaluated organoleptically. The products were offered to a panel of judges and according to their preference sensory parameters are depicted in the Table 6.

The score for colour of squash beverage was recorded as 7.38, 7.30, 7.14, 7.65 & 8.16 for T_o, T_1, T_2, T_3 & T_4, respectively. The score for flavour was 6.25, 6.67, 6.82, 7.27 and 7.54 for T_o, T_1, T_2, T_3 and T_4, respectively. The score for the taste ranged from 5.02 to 7.93 for T_o to T_4, respectively. Scores revealed that T_3 was most acceptable followed by T_4 (7.86) to T_1 (6.56). The score for the consistency was ranged from 7.60 (T_0) to 7.83 (T_3).

***Giloy* Syrup**

An effort was also made to prepare *Giloy* syrup blended with the *kinnow* to improve the appearance and the nutritional value.

Nutritional evaluation of freshly prepared *Giloy: Kinnow* based Syrup

Table 7 includes values for the different nutritional components under different treatments of syrup beverage.

The values for total soluble solids were observed to be 68.01 (T_o), 68.01 (T_1), 68.02 (T_2), 67.67 (T_3), 68.04 (T_4) ^{o}Brix for the squash beverage. The pH value for the syrup beverage were observed as 5.60 (T_o), 5.74 (T_1), 4.69 (T_2), 3.58 (T_3) and 2.24 (T_4), respectively. The per cent acidity values for syrup were observed as 0.29, 0.43, 0.69, 1.04, 1.47 for T_o, T_1, T_2, T_3, T_4, respectively. The values for the ascorbic acid were observed to be 4.50, 4.57, 4.57, 4.53, 5.43 mg/100g for treatment T_o, T_1, T_2, T_3, T_4, respectively. The per cent value for total sugars were recorded to be 62.54, 62.43, 61.12, 61.71,

Table 6. Sensory scores of freshly prepared *Giloy: Kinnow* based squash

Parameters	Treatments				
	T_0	T_1	T_2	T_3	T_4
Color	7.38	7.30	7.14	7.65	8.16
Flavour	6.25	6.67	6.82	7.27	7.54
Taste	5.02	6.21	7.16	7.61	7.93
Consistency	7.60	7.66	7.63	7.83	7.80
Overall acceptability	6.56	6.96	7.19	7.59	7.86

Each value representing the mean of three values

Table 7. Nutritional parameters of freshly prepared *Giloy: Kinnow* based Syrup

Parameters	Treatments				
	T_0	T_1	T_2	T_3	T_4
TSS (^{0}Brix)	68.01	68.01	68.02	67.67	68.04
pH	5.60	5.74	4.69	3.58	2.24
Acidity (%)	0.29	0.43	0.69	1.04	1.47
Ascorbic acid (mg/100g)	4.50	4.57	4.57	4.53	5.43
Total sugars (%)	62.54	62.43	61.12	61.71	61.41
Reducing sugars (%)	28.44	27.45	26.95	26.29	26.49
Non-reducing sugars (%)	35.89	36.83	35.97	37.28	36.78

Each value representing the mean of three values

61.41 per cent for T_o, T_1, T_2, T_3, T_4, respectively. The values for reducing sugars were 28.44, 27.45, 26.95, 26.29, 26.49 and for the non-reducing sugars 35.89, 36.83, 35.97, 37.28, 36.78 for T_o, T_1, T_2, T_3, T_4, respectively.

Organoleptic evaluation of freshly prepared *Giloy: Kinnow* based Syrup

The organoleptical evaluation according to the panel/ consumer acceptance has been depicted in Table 8. Score for colour of squash beverage was 7.04, 7.28, 7.28 7.57 and 7.78 for T_o, T_1, T_2, T_3 and T_4, respectively. The trend was similar for flavour, taste and consistency, T_0 having lowest score and T_4 had highest.

Score for overall acceptability showed that the T_4 was most acceptable with score 7.97 followed by T_3 with score 7.79. The score for consistency was ranged from 7.60 to 7.83 for all the five treatments.

From the beverages *viz.* Ready to Serve (RTS), squash and syrup made from *Giloy*, it was found that control beverages i.e. 100% *Giloy* have the best consistency when compared with other blend ratio. The value added products prepared from *Giloy* could be exploited commercially in order to add variety, improve overall health and can be good alternatives for the health conscious persons.

Table 8. Sensory scores of freshly prepared *Giloy: Kinnow* based Syrup

Parameter	Treatment				
	T_0	T_1	T_2	T_3	T_4
Color	7.04	7.28	7.28	7.57	7.78
Flavour	6.17	6.54	6.92	**7.64**	7.96
Taste	6.25	6.29	6.67	7.34	7.87
Consistency	7.13	7.56	7.92	8.62	8.26
Over all acceptability	6.65	6.92	7.19	7.79	7.97

Each value representing the mean of three values

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Factors affecting socio-economic status of farm workers of tea industry in Himachal Pradesh

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Abstract

The present study was carried out in Kangra district of Himachal Pradesh to analyse the various dimensions of human workforce employed in tea plantation and processing. 100 farmers, 50 each from production and processing were randomly selected. The study showed that the education status of the respondents was extremely low particularly those of women. Workforce engaged in processing was comparatively more qualified (upto the metric standard) than those engaged in production. Most of the workforce had only traditional knowledge and skill to work in the tea plantation. 80% of the workforce employed in tea processing was male. 74% of workforce was casual due to the seasonal requirement of the human resource in the tea factories. Tea industry was contributing 64% of total income of the casual workforce. The permanent workforce was earning 57% more than the casual. Due to more income and privilege of compulsory saving in GPF/CPF or EPF, permanent workforce saves more than the casual workforce.

Key words: Tea industry, Socio-economic status, Human workforce

Tea is one of the cheapest beverages in the world. At present 45 countries grow tea over an area of 1.4 million (m) ha with annual production of 3726.7 m kg. China stands first with 1094 m kg of tea production (29.4% of total tea production in world) followed by India with 944.7 m kg (25.3%). For a number of developing countries it is an important commodity in terms of jobs and export earnings (Majumder and Roy, 2012). In India tea is grown on an area of 0.427 m ha and is considered as one of the major foreign exchange earning commodities**.** A survey conducted by the Indian Tea Board reveals that 89% of the people take tea as their habit, 8% for refreshing their minds and 3% for appeasing hunger (Sarma, 2013).Tea industry of Himachal Pradesh is about 150 years old. Its cultivation in this region was started in 1849, when Dr. Jameson, the then Superintendent of the Botanical Gardens North – West Province, Peshawar visited the area to ascertain its suitability for cultivation after observing preliminary success of tea plants at nursery stage introduced from China. He recommended the lower slopes of Dhauladhar ranging between 900-1400 m altitude receiving annual precipitation of 1500-2500 mm and soil pH below 6.0, as the most suitable areas for its cultivation.

In Himachal Pradesh, tea (*Camellia Sinensis* (L) O Kuntze) is grown in mid hills, sub-humid soils of Kangra and Mandi districts covering an area of about 2310 ha and producing 1.464 m kg of made tea (Dixit *et al*. 2006). Out of this an additional area of about 3200 ha in Chamba district has been identified as non-traditional land suitable for tea cultivation in Himachal Pradesh (Sharma *et al*. 1999). The first commercial tea plantation was established as 'Hailey Nagar Tea Estate' at Holta, near Palampur, in 1852 at an altitude of 1291 m (Anonymous, 2000). The produce from this plantation was sold at a very high premium price. It encouraged many private entrepreneurs with the result that by the end of 1880, about 4183 ha of area was brought under tea cultivation extending from Jogindernagar in Mandi district to Shahpur in Kangra district.

Himachal tea industry has got tremendous potential of employment opportunities. At present about 7000 workers are directly or indirectly associated with this industry. Tea industry provides the employment opportunity to almost every section of the society i.e. form illiterate (to work in plantation) to technical personnel, to work in the processing unit and R & D institutes for quality and productivity improvement.

There is a tremendous scope for the other professionals such as management, trading and transport. With the emergence of new concept of agro-eco-tourism, the beautiful green carpet of tea plantation fully equipped with all basic facilities of recreation and natural environment, is well suited to exploit this venture to generate more employment for youths as well as to boost the tourism industry of the state. The concept of organic farming will definitely enhance the employment opportunities for the youths to work in tea plantation. Keeping this in view, the present study was carried out to study the demographic structure and socio-economic status of human resource engaged in the tea plantation and processing.

Materials and Methods

In this study an attempt has been made to analyse the various dimensions of human resource development with special reference to economic and social status of workforce employed in tea plantation and processing industry of Himachal Pradesh. The study was carried out in Kangra, district of Himachal Pradesh. The Kangra district was selected because it the major district growing tea. The simple random sampling was employed for the selection of farmers. Total 100 workers were selected randomly to carry out this study. Out of total sample size, 50 workers each form tea plantation and processing unit were selected proportionately from private, co-operatives and government units.

Workers were further classified in three age groups as follows

Group		**Age**
A	:	20-30 Years
B	:	31-45 Years
C	:	46-60 Years

The workers were interviewed with the help of structured questionnaire/schedule to collect the data from regular and casual labour working in the tea industry of Himachal Pradesh. Simple percentages and averages were calculated to analyse the data.

Results and Discussion

The finding of study has thrown valuable light on the socio-economic status of workers in tea industry of Himachal Pradesh. It has also helped in analysing and evaluating the impact of social and economic securities granted to the workers in the palpation/processing unit. The findings of study shall be useful in identifying the remedial measure to improve the social status of workers so that unemployed youth can be attracted to work in tea industry.

Demographic structure

The education status of the respondents was extremely low particularly among women (Table 1).

Table 1. Demographic structure of human workforce in Tea business in Himachal Pradesh

Particular	Distribution	Tea Processing				Tea Plantation			
		N=50	A (n=17)	B (n=23)	C (n=10)	N=50	A (n=11)	B (n=23)	C (n=16)
Age group (%)	A	34	100.0	0.0	0.0	22	100.0	0.0	0.0
	B	46	0.0	100.0	0.0	46	0.0	100.0	0.0
	C	20	0.0	0.0	100.0	32	0.0	0.0	100.0
Gender (%)	Male	80	88.2	86.9	50.0	24	27.3	21.7	25.0
	Female	20	11.8	13.1	50.0	76	72.7	78.3	75.0
Education (%)	Middle	60	29.4	65.2	10.0	66	45.5	65.2	81.3
	Metric	30	58.8	21.8	0.0	26	45.5	21.8	31.3
	10+2	10	11.8	13.0	0.0	8	9.0	13.0	0.00
Employment status (%)	Casual	74	100.0	78.3	20.0	86	100.0	87.0	62.5
	Permanent	26	0.0	21.7	80.0	14	0.0	13.0	37.5

Similar results were reported by Devi (2014) who found that most of the women workers engaged in tea were illiterate. Of the respondents engaged in processing, 60% were in the class of illiterate to middle. Among the workforce engaged in production, 66% was of having middle standard education. Percentage of the qualification up to Metric standard workforce was higher in number in the processing (30%) as compared to the plantation (26%). None of tea workforce was having college education. Middle class workforce neither having any technical knowledge regarding plantation and processing management nor any training for other modern occupation. Most of the workers were equipped with the only traditional knowledge and skill to work in the tea plantation.

In processing age group B represents 46% of working strength followed by A and C. As for as gender is concerned, 80% of the workers employed in tea processing unit were male. The main reason for the major proportion of male workers in the unit is that the processing is a continuous process and carried out 24 hrs of the day during the season and needs high manual strength. As per the employment status is concerned, 74% of workers comes under the category of casual labour due to the seasonal requirement of the human resource in the tea factories.

In production, the strength of female workers was high (76%) as compared to the male workers (24%). The reason for the more female workers in tea production is the efficiency of female worker to pluck the good quality tea leaves. Majority of the workers (86%) engaged in production were due to seasonal field operations in tea.

Socio Economic Status

Income

For both permanent and casual workforce, major proportion of income was contributed by the tea industry. Perusal of Table 2a showed that tea industry contributes 66% and 64% of total income/month of the permanent and casual workforce, respectively. On an average permanent workers were earning 57% more than the casual workers. Family expenditure of permanent workers was 61% of their total earnings. The casual workers restrict their house hold expenditure to 54% less than the permanent workers (Majumder and Roy, 2012). However, their expenditure was 66% of their total income.

Saving system

Perusal of Table 2b revealed that all permanent workers had opted the pay saving schemes whereas, 69% of casual workforce had savings in commercial banks. Saving was more in case of permanent workers which may be due to the prevalence of saving schemes, to which permanent workers are bound to contribute up to minimum of 10% of their salary as GPF/CPF or EPF. Such saving schemes as available (i.e PPF) are not opted by the contractual/casual workers due to lower income as well as ignorance.

Social status

Regarding mode of conveyance, 48% of permanent labour had owned two wheelers, whereas it comes out to be 23% for casual workers. The reason of high percentage of two wheeler holders was the availability of money to meet the expenditure of vehicle and prevalence of easy finance schemes exclusively for permanent employees by the different banks and financing agencies. Nearly 85% of the permanent workforce possessed their own house, out of which 24% were newly constructed due to mild house loan schemes for permanent employees from cooperatives, nationalized, state and private banks. But in case of casual workers 60% possessed their parental house.

Regarding the basic facilities provided to the workers of tea industry, most of the permanent workers were satisfied with the medical facilities, fair price shop, drinking water supply and power supply. There was need to improve these facilities for casual workers.

As for as the security measures are concerned consensus of casual as well as permanent workers was more or less same. There was need to improve the fire protection measures in the processing unit for the safety of the workers. As per information collected regarding the satisfaction level of the workers in the tea industry, all the permanent workers were satisfied with their working condition and present employment, but 82% of the casual workforce wanted to shift from the industry subject to the better employment opportunity. So there was need to formulate socio-economic development schemes in tea industry.

From all above it can be inferred that while permanent workforce was quite satisfied with their present employment and working environment, casual workforce in Himachal tea industry wanted to shift from the industry subject to the better employment opportunity elsewhere.

Table 2a. Socio economic status of permanent and casual workforce in tea plantation and processing

Particular	Permanent workers (N=33)		Casual workers (N=67)	
	INR/month	Percent contribution	INR/month	Percent contribution
Source of Income				
Agriculture	700	7.7	600	15.3
Salary/wages	6000	65.5	2500	63.7
Family Pension	1500	16.4	450	11.5
Other	955	10.4	375	9.5
Total	9155	100.0	3925	100.0
Average expenditure				
Food	3000	53.7	2000	77.5
House Rent	250	4.5	55	2.1
Education	600	10.8	200	7.8
Clothing	250	4.5	105	4.1
Social ceremonies	350	6.3	76	2.9
Repayment of loan	857	15.3	0	0.0
Miscellaneous	275	4.9	145	5.6
Total	5582	100.0	2581	100.0
Average family size (No.)				
Male	3.5	63.3	3.5	58.6
Female	2.0	36.7	2.5	41.4
Total	5.5	100.0	6.0	100.0

Table 2b. Socio economic status of permanent and casual workers in tea plantation and processing unit

Particular	Permanent		Casual	
	(N=33)	Percent contri-bution	(N=67)	Percent contribution
Mode of saving				
GPF/CPF/EPF	33	100.0	0	0.0
Commercial Bank	33	100.0	46	68.7
Rural/Agri. Banks	15	45.5	25	37.3
Co-operative bank	17	51.5	22	32.8
Source of financial assistance (Loan)				
Commercial Bank	20	60.6	0	0.0
Rural/Agri. Banks	3	9.1	0	0.0
Co-operative bank	10	30.3	0	0.0
Social status				
Two wheeler	16	48.5	15	22.4
Four Wheeler/travelling	0	0.0	0	0.0
Four Wheeler for transportation	0	0.0	0	0.0
Own house	28	84.9	40	59.7
Parental	20	60.6	40	59.7
Purchased/new constructed	8	24.2	0	0.0
Rented house	5	15.2	27	40.3
By the employer (Rent)	2	6.1	20	29.9
Private rented	3	9.1	7	10.5
Basic facilities available				
Hospital	30	90.9	40	59.7
School	0	0.0	10	14.9
Govt. fair shop	30	90.9	40	59.7
Good drinking water	33	100.0	57	85.1
Proper electricity	33	100.0	59	88.1
First aid	20	60.6	45	67.2
Security in working place				
Wild animal	25	75.8	56	83.6
Snakes	20	60.6	40	59.7
Fire	15	45.5	25	37.3
Water flood	33	100.0	62	92.5
Satisfaction with work				
Family allow to work	33	100.0	60	89.6
Satisfied with work	30	90.9	52	77.6
Opportunity of growth	10	30.3	20	29.9
Management satisfied with your work	33	100.0	67	100.0
Salary/wages	23	69.7	24	35.8
Working hrs.	26	78.8	48	71.6
Govt. Policies	27	81.8	10	14.9
Want to shift from industry	6	18.2	55	82.1

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Assessment of yield and nutrient losses due to weeds in maize based cropping systems

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Abstract

The present study was carried out in a continuing experiment at the Bhadiarkhar farm of the Department of Agronomy, CSKHPKV, Palampur during 2012-13 and 2013-14. The soil was silty clay loam in texture, high in OC (0.99%), medium in available N (305.1 kg/ha) and high in available P (78.5 kg/ha) and K (117.4 kg/ha). There were eight cropping systems [C_1- Maize – Wheat, C_2 - Maize (Green cob) + Frenchbean (Pol) – Pea – Summer squash; C_3 - Maize + Soybean – Garlic; C_4 - Maize (Green cob) – Broccoli – Potato; C_5 - Maize + Asparagus bean – Radish – Onion; C_6 - Maize (Green cob) + Urd bean – Cauliflower – Frenchbean; C_7 - Maize (Green cob) + Ricebean – Cauliflower – Buckwheat and C_8 - Maize (Green cob) + Asparagus bean – Broccoli – Radish] being tested in RBD with four replications. In each experimental plot three weed management situations (S_1 - normal weed control, S_2 - no weed control/weedy check and S_3 - supplement weed control) were maintained and observations on crops and weeds were recorded. There were 28 weed species which invaded different maize based cropping systems. During *kharif*, S_2 situation encompasses 6-7 weeds during 2013, S_1 6-7 during 2012 and 8-9 during 2013, whereas in the S_3 only 3-4 species were present during both years. *Commelina benghalensis* (56% and 41% during 2012 and 2013, respectively) and *Ageratum* (21% and 33%) were the predominant weeds. In rabi, *Coronopus didymus*, *Phalaris minor* and *Spergula arvensis* (54, 22 and 14%, respectively during 2012-13 and 31, 7 and 28% during 2013-14) were the main weeds. Irrespective of the situation, under the new cropping systems 5-10 weed species were similar whereas, 0-5 species were new as compared to the prevalent maize – wheat cropping system during the *rabi* season. Maize + asparagus bean – radish – onion gave 245 and 503.9% higher maize grain equivalent yield over maize - wheat during 2012-13 and 2013-14, respectively. N depletion by weeds ranged from 608 to 695 and 309.1 to 461.2, P from 121.6 to 177.1 and 71.1 to 99.6 and K from 202.7 to 432.5 and 118.4 to 166.0 kg/ha/annum, during 2012-13 and 2013-14, respectively. Weeds inflicted huge yield losses ranging from 15.7% in C_6 to 35.6% in C_1.

Key words: Maize based cropping systems, Weeds, Shannon Weir Index, Nutrient losses, Yield losses

Maize- wheat is the most predominant cropping system in mid hills of Himachal Pradesh. There were significant research achievements in the past, but the productivity of maize–wheat system is far below the potential yield of the crops. Recommendations on improved crop production technologies have been made (HPKV, 2007a, b &c), but the farmers have not succeeded in taking full advantage of these scientific interventions (Singh *et al*, 1998). Despite enormous growth of maize-wheat system, reports of stagnation in the productivity, with possible decline in production in future, have raised doubts on its sustainability. Earlier studies have indicated superiority of alternative vegetable based cropping systems over the traditional cropping systems (Rana *et al*. 2010 & 2011, Sharma *et al*. 2007 & 2009). Such declining trend in productivity associated with decline in factor productivity may be attributed largely to emergence of multi-nutrient deficiencies and building up of soil pathogens and weed flora besides increasing soil health problems.

Weeds are the most limiting factors in crop production (Buhler, 1992). If left uncontrolled, the weeds in many fields are capable of reducing yields by more than 80% (Karlen *et al*. 2002). With prolonged cultivation of maize-wheat system, many weed species have increased to a greater extent. Nevertheless with diversification of the system, the behaviour of weeds in maize as a function of preceding *rabi* and summer season crop may change. The crop(s), cropping systems and varying management practices like organic inputs, tillage conditions, water control,

crop rotation, fertilizer application and herbicide use have been reported to affect significantly weed communities in a range of agroecosystems (Lesson et al. 2000; Liebman and Davis, 2000). In Indian region, except few (Srivastava and Singh, 2005) scanty information is available on comparative evaluation of weed diversity in different cropping systems. Studying the weed diversity/ dynamics is helpful to understand the dominance or absence of a particular weed species in a cropping system. Estimating nutrient and yield losses due to weeds is equally important for having better strategy for their management.

Materials and Methods

A study was carried out in a continuing experiment, at the Bhadiarkhar farm of the Krishi Vishvavidyalaya. Eight cropping systems [C_1- Maize – Wheat (M-W), C_2 - Maize (Green cob) + Frenchbean (Pole) – Pea – Summer squash (Mgc+Fb-P-Ss); C_3 - Maize + Soybean – Garlic (M+S-G); C_4 - Maize (Green cob) – Broccoli – Potato (MGc-Br-Po); C_5 - Maize + Asparagus bean – Radish – Onion (M+Ab-Ra-O); C_6 - Maize (Green cob) + Mash – Cauliflower – Frenchbean (Mgc+Ub-C-Fb); C_7 - Maize (Green cob) + Ricebean – Cauliflower – Buckwheat (Mgc+Rb-C-Bw) and C_8 - Maize (Green cob) + Asparagus bean – Broccoli – Radish (Mgc+Ab-Br-Ra)] were evaluated in a randomized block design with four replications. The soil of the experiment site was silty-clay loam with pH 5.38, OC 0.99%, Available N 305.1, P 78.5 and K 117.4 kg/ha. The crops were raised in accordance with the recommended package of practices for the region.

Yields were harvested from net plot. For comparison between cropping sequences, the yields of crops were converted into maize-grain equivalent yield on price basis. Relative productivity efficiency (RPE) and relative energy output (REO) were determined as below:

RPE (%) = (Total productivity of diversified cropping system - total productivity of existing cropping system)/Total productivity of existing cropping system x 100

REO (%) = Total energy output of the main product under the diversified cropping system/Total energy output of the main products under the existing cropping system x 100

For weed studies three situations were established *i.e* S_1 Usual weed control practice (*kharif* as well as *rabi*) using herbicides or manual weed control, S_2 No weed control/weedy without herbicide spray or hand weeding (*kharif* as well as *rabi*) and S_3 Additional weed control usually handweeding after herbicide spray or manual control (*kharif* as well as *rabi*). These situations were established in each plot and data on weed count and dry weight were recorded. Species-wise weed count was taken at monthly interval from 40 cm x 40 cm quadrate/area in each situation at two sites. The weed count so obtained was converted into No./square metre by multiplying the average count of the weed with factor 6.25. The samples for weed dry weight at monthly interval were taken by placing 25 cm x 25 cm quadrate at random at two sites in each situation. These samples were oven dried at a temperature of 70 ^oC till constant weight. The dry matter thus recorded was multiplied by the factor 16.0 to obtain weed dry weight/square metre. The uptake of N, P and K was calculated by multiplying nutrient content with corresponding dry weight.

Results and Discussion

Surveillance and distribution of weed species

There were 28 weed species found growing in association with different maize based cropping systems during a period of two years. This clearly indicated the greater diversity of weed flora that invaded crops and cropping systems in the present investigation. The proportion of different *kharif* and *rabi* weeds at the maximum population stage which was observed in August and January, respectively under undisturbed situation (S_2) had been shown in Fig 1. It was clearly indicated that during *kharif, Commelina* was the most dominant weed during both the seasons with infestation to the tune of 56 and 41% during 2012 and 2013, respectively. *Ageratum* sp was next in dominance with invasion percentage of 21 and 33 during 2012 and 2013, respectively. *Cyperus* sp constituted 12% of the total weed flora during 2012 and 6% during 2013. The magnitude of *Bidens pilosa* observed during the course of investigation was to the tune of 4% during both the years. *Aeschynome indica* (5%) during 2012 and *Echinochloa* sp (8%) and *Gallinsoga parviflora* (3%) during 2013 were the other important weeds. The remaining weeds as a whole constituted 2 and 5% of the total weed flora during *kharif* 2012 and 2013, respectively. In rabi, *Coronopus*, *Phalaris* and *Spergula* were the main weeds constituting 54, 22 and 14%, of the total weed flora during 2012-13 and 31, 7 and 28%, respectively during 2013-14. It is clearly indicated that the population of *Coronopus* and *Phalaris* while decreased, that of *Spergula* increased by two fold during the second year as compared to the first year. The proportion of *Avena*, *Anagallis* and *Vicia* was also found higher during the second year. *Trifolium* sp

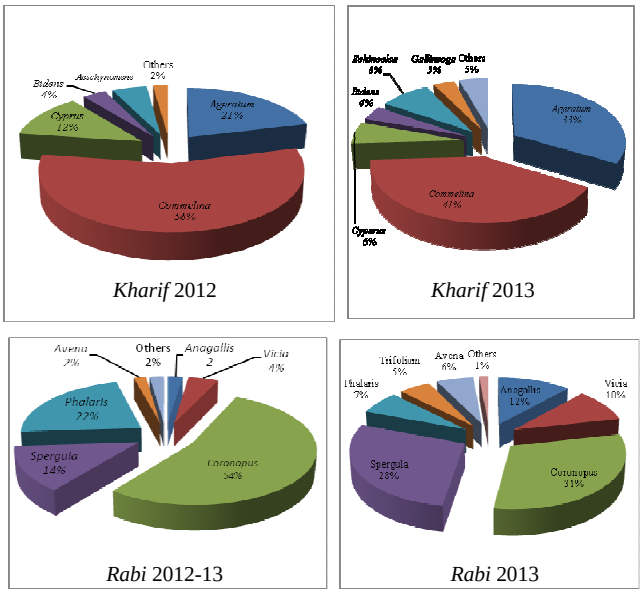

Fig 1: Proportion of weeds under undisturbed situation at maximum population during *kharif* (August) and *rabi* (January)

constituted 5% of the total weed flora only during 2013-14. The present investigation clearly revealed that the weeds are dynamic in nature and are greatly influenced by crops and cropping systems, season and management practices being carried out during the crop growth. The other weeds found associated with different crops as a whole constituted 2 and 1% of the total weed flora during 2012-13 and 2013-14, respectively.

Weed diversity: Shannon Weir Index

During *kharif* S_1 had larger number of weeds than S_2 whereas S_3 situation has fewer numbers of weeds (Table 1). S_2 situation encompasses 6-7 weeds during 2013, S_1 6-7 during 2012 and 8-9 during 2013, whereas in the S_3 only 3-4 species were present during both years. S_2 is a situation where weeds were allowed to grow uninterrupted and owing to competition or the other aspects of interference the weaker competitors might have been eliminated. When the weed competition is reduced by standard means in the S_1, second flush of weeds as in S_2 emerged along with some additional weeds. Under such circumstances *Gallinsoga parviflora*, *Echinochloa crusgalli*, *Cynodon dactylon* and *Polygonum* sp. were the important weeds. When the weeds were controlled by use of additional handweeding/hoeing in S_3, the weeds appeared were *Ageratum conyzoides*, *Bidens pilosa*, *Ageratum houstonianum*, *Polygonum* sp, *Echinochloa crusgalli*, *Cyperus* sp. This indicated that these weeds

Table 1. Cropping systems influence on Shannon Weir Index in *kharif* and *rabi* season weeds under different situations

Cropping system	*Kharif*												*Rabi*					
	Species common as C_1					*New species those absent in C_1*			*Species common as C_1*			*New species those absent in C_1*					
	2012		2013			2012			2013			2012-13			2013-14		
	S_1	S_3	S_1	S_2	S_3	S_1	S_3	S_1	S_2	S_3	S_1	S_3	S_1	S_3	S_1	S_3	S_1	S_3
M-W	7	4	9	7	4						13	12	11	11				
Mgc + Fb – P – Ss	7	4	9	7	4	2	0	0	0	0	10	10	7	8	4	2	1	0
M+S – G	7	3	9	6	4	2	0	0	0	0	9	10	8	9	1	1	0	0
Mgc – Br – Po	7	4	8	7	4	2	0	0	0	0	9	10	7	8	5	2	1	0
M + Ab – Ra – O	6	4	9	7	4	1	0	0	0	0	8	9	9	9	3	2	1	0
Mgc + Ub – C – Fb	7	4	9	7	4	0	0	0	0	0	9	10	8	8	5	1	1	0
Mgc + Rb – C – Bw	7	4	8	7	4	2	0	0	0	0	8	10	6	8	4	1	0	0
Mgc + Ab – Br – Ra	7	4	9	6	4	1	0	0	0	0	5	11	8	9	5	1	0	0

were the robust robbers. In spite of repeated means of control, they were not eradicated. Therefore, management strategies should be geared up towards integrated means to keep them under check.

Weed flora during *rabi* was richer than that during *kharif*. Some of the weeds like *Ageratum houstonianum*, *Ageratum conyzoides*, *Polygonum* sp and *Gallinsoga parviflora* those invaded the experimental field during *kharif* were also present during *rabi*. There were contrasting differences between the situations. The weeds such as *Bidens pilosa*, *Gallinsoga parviflora*, *Stellaria media*, *Alopecurus myosuroides*, *Lolium temulentum*, *Ageratum* sp, *Polygonum* sp, *Avena ludoviciana*, *Cynodon dactylon* etc which appeared in the S_1 situation (standard weed control practice) were completely eliminated when additional control effort was tried in S_3. However, when additional weed control measure was adopted in the S_3, species like *Rumex* sp, *Poa annua*, *Polygonum plebegium*, *Trifolium repens*, *Polypogon monspelensis* invaded the fields and a range of crops. Irrespective of the situation, under the new cropping systems 5-10 weed species were similar whereas, 0-5 species were new as compared to the prevalent maize – wheat cropping system during the *rabi* season.

Maize grain equivalent yield

It was evident from Table 2 that there was sufficient scope to replace maize-wheat cropping system with other cropping systems without any decline in economic yield. All cropping sequences were significantly superior to the traditional maize – wheat cropping sequence in influencing maize grain equivalent yield. Maize + asparagus bean – radish –onion gave 245 and 503.9% higher maize grain equivalent yield over the traditional maize - wheat cropping sequence during 2012-13 and 2013-14, respectively. The higher yield under the system was owed to higher tonnage of vegetables such as radish and onion. Owing to higher yield, maize + asparagus bean – radish –onion had highest relative productivity efficiency and was followed by C_8, C_4, C_6 and C_3 during 2012-13 and C_2, C_4, C_7 and C_8 during 2013-14.

Total energy output of the main product was highest under 'maize-wheat' cropping system (28.9 and 21.5 x 10^6 kcal/ha/annum during 2012-13 and 2013-14, respectively). Total energy output due to the new cropping systems was significantly lower than 'maize – wheat'. 'Maize + Asparagus beans - radish – onion, the better cropping sequences in terms of maize grain equivalent had only 55 and 92.6% of the total energy output under the conventional 'maize-wheat' cropping system during 2012-13 and 2013-14, respectively. However, this cropping system was superior to other cropping systems except maize + soybean – garlic during 2012-13. As indicated by relative energy output, C_6-C_8 and C_2 produced only 19-37% of the total energy output of the 'maize - wheat' cropping system. This indicated that complete diversification of 'maize – wheat' cropping system is neither possible nor advisable. Only 15-20% of the net sown irrigated area may be diversified by small and marginal farmers taking into account the comparative advantage to meet out their cash requirement. These results are in conformity with earlier findings (Rana *et al* 2011).

Nutrients losses by weeds

Marked influence of different cropping systems was observed on the NPK depletion by weeds during *kharif* in the first year and during *rabi* in the second year of study under the S_2 situation (Table 3). The total yearly NPK uptake was significant due to cropping system in both the years. The nutrient losses due to weeds were huge under the cropping systems. Since nutrient depletion/removal/ uptake is a function of dry weight and content, it followed the trend of dry weight influenced by content. Nitrogen depletion by weeds ranged from 608 – 695 and 309.1 – 461.2 kg/ha/annum during 2012-13 and 2013-14, respectively. Phosphorus depletion was in the range of 121.6 – 177.1 and 71.1 – 99.6 kg/ha/annum during 2012-13 and 2013-14, respectively. Potassium depletion varied from 202.7 – 432.5 and 118.4 – 166.0 kg/ha/annum during 2012-13 and 2013-14, respectively.

Yield losses by weeds

Losses in yield due to weeds were estimated based on yield as realized under S_3 situation and that estimated under the S_2 situation. Weeds inflicted huge losses in yield (Table 4) ranging from 12.8 (C_3) to 41.4% (C_5) during 2012-13 and from 12.6 (C_7) to 39.4% (C_2) during 2013-14 based on maize grain equivalent yield. Mean maize grain equivalent yield loss varied from 15.7% in C_6 cropping system to 35.6% in the C_1 cropping system. Minimum yield loss of 6.7% was in case of maize green cob under the C_6 cropping system during 2012-13 and maximum yield loss of 76.8% was of asparagus bean under the C_5 cropping system.

The present investigation conclusively inferred that the weeds are dynamic in nature and are greatly influenced by cropping system, season and management practices carried out during the crop growth. They inflict huge nutrient and yield losses suggesting to adopt strong management strategies.

Table 2. Yield (kg/ha) and energy output (10^6 K cal/ha/annum) of main product under different crop sequences

Crop sequence		Yield main product (kg/ha/annum)					RPE (%)	Energy out-put	REO (%)
		Kharif	*Intercrop*	Rabi (I)	Rabi (II)	MGEY*			
				2012-13					
C_1	M-W	2273		6014		9339	-	28.9	-
C_2	Mgc + Fb – P - Ss	3598	185	3575	4967	16085	72.2	6.2	21.5
C_3	M+S - G	2367	284	4442		16404	75.7	16.1	55.7
C_4	Mgc – Br - Po	3428		5663	8636	23390	150.5	10.7	37.0
C_5	M + Ab – Ra - O	2367	152	18939	10606	32216	245.0	15.9	55.0
C_6	Mgc + Ub – C - Fb	3589	133	8902	2221	17396	86.3	5.6	19.4
C_7	Mgc + Rb – C - Bw	3703	161	9091	1894	14977	60.4	5.5	19.0
C_8	Mgc + Ab – Br - Ra	3485	133	6553	8902	27538	194.9	6.0	20.8
	LSD (P=0.05)					2984		1.9	
				2013-14					
C_1	M-W	2462		3681		6879	-	21.5	-
C_2	Mgc + Fb – P - Ss	4782	284	947	21412	32939	378.8	7.9	36.7
C_3	M+S - G	2462	142	2376		9974	45.0	12.8	59.5
C_4	Mgc – Br - Po	4877		4640	12045	28612	315.9	13.9	64.7
C_5	M + Ab – Ra - O	2462	151	19081	19697	41544	503.9	19.9	92.6
C_6	Mgc + Ub – C - Fb	4877	134	4735	2221	15491	125.2	5.4	25.1
C_7	Mgc + Rb – C - Bw	4830	160	4735	5066	20998	205.2	5.6	26.0
C_8	Mgc + Ab – Br - Ra	4924	130	4735	1515	16477	139.5	5.0	23.3
	LSD (P=0.05)					2101		0.9	

**MGEY, maize grain equivalent yield*; RPE, relative productivity efficiency; REO, relative energy output

Table 3. Cropping systems' influence on NPK losses by weeds

Cropping system	N (kg/ha)		P (kg/ha)		K (kg/ha)	
	2012	2013	2012	2013	2012	2013
			Kharif			
M-W	256.9	294.4	51.4	67.9	85.6	113.2
Mgc + Fb – P – Ss	245.9	272.8	49.2	63.8	82.0	106.3
M+S – G	322.5	307.7	64.5	68.9	107.5	114.8
Mgc – Br – Po	258.5	315.2	51.7	69.4	86.2	115.6
M + Ab – Ra – O	324.6	296.2	64.9	65.9	108.2	109.8
Mgc + Ub – C – Fb	333.0	326.4	66.6	70.3	111.0	117.2
Mgc + Rb – C – Bw	313.4	310.5	62.7	70.1	104.5	116.8
Mgc + Ab – Br – Ra	309.1	307.4	103.0	68.4	309.1	114.1
LSD (P=0.05)	36.4	NS	7.2	NS	12.1	NS
			Rabi			
M-W	365.6	149.8	73.1	30.0	121.9	49.9
Mgc + Fb – P – Ss	362.1	36.3	72.4	7.3	120.7	12.1
M+S – G	359.8	153.5	72.0	30.7	119.9	51.2
Mgc – Br – Po	353.9	36.3	70.8	7.3	118.0	12.1
M + Ab – Ra – O	361.9	101.3	72.4	20.3	120.6	33.8
Mgc + Ub – C – Fb	360.7	40.3	72.1	8.1	120.2	13.4
Mgc + Rb – C – Bw	382.0	33.0	76.4	6.6	127.3	11.0
Mgc + Ab – Br – Ra	370.3	36.8	74.1	7.4	123.4	12.3
LSD (P=0.05)	NS	18.3	NS	3.7	NS	6.1
			Total			
M-W	622.5	444.2	124.5	97.9	207.5	163.1
Mgc + Fb – P – Ss	608.0	309.1	121.6	71.1	202.7	118.4
M+S – G	682.3	461.2	136.5	99.6	227.4	166.0
Mgc – Br – Po	612.4	351.5	122.5	76.7	204.2	127.7
M + Ab – Ra – O	686.5	397.5	137.3	86.2	228.8	143.6
Mgc + Ub – C – Fb	693.7	366.7	138.7	78.4	231.2	130.6
Mgc + Rb – C – Bw	695.4	343.5	139.1	76.7	231.8	127.8
Mgc + Ab – Br – Ra	679.4	344.2	177.1	75.8	432.5	126.4
LSD (P=0.05)	58.9	30.7	11.8	11.3	19.6	11.4

Table 4. Losses (%) in yield due to weeds (Mean of two years)

Crop sequence		Crop/season				
		Kharif	*Intercrop*	Rabi (I)	Rabi (II)	Overall
C_1	M-W	19.6		42.2		35.6
C_2	Mgc + Fb – P - Ss	9.8	62.3	17.2	45.4	34.6
C_3	M+S – G	20.0	43.7	19.0		20.2
C_4	Mgc – Br – Po	17.2		40.9	35.8	34.5
C_5	M + Ab – Ra – O	14.3	63.7	31.6	21.1	26.4
C_6	Mgc + Ub – C - Fb	11.7	62.2	9.3	25.4	15.7
C_7	Mgc + Rb – C - Bw	21.8	58.9	18.0	17.5	18.2
C_8	Mgc + Ab – Br - Ra	23.9	62.0	19.2	25.4	22.9

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Analysis of yield gaps in black gram (*Vigna mungo*) in district Bilaspur of Himachal Pradesh

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Abstract

Black gram (*V. mungo)* is one of the important pulse crops in India which plays an important role in supplementing the income of small and marginal farmers. Non adoption of improved varieties and recommended practices is one of the reasons for low productivity in this crop. Improved technological package was compared with that of farmers' practice in the Bilaspur district of Himachal Pradesh during *kharif* 2006 to 2009. The results revealed that the use of improved variety, line sowing and balanced application of fertilizers under the improved practice increased seed yield of mash by 34.1 to 81.6% over farmer practice. Improved technological package gave 33.7% higher gross return and 70.4% higher net return over the prevalent practice of the farmers. The average additional cost and additional net return of INR 3003 and INR 10715 were recorded from 2006 to 2009. Incremental benefit cost ratio (IBCR) ranged from 3.10 to 4.64 with an average value of 3.55. The water use efficiency has also been increased by using the improved agricultural technologies in the demonstrations.

Key words: Technology gap, extension gap, technology index, Black Gram.

Food legumes are the vital source of protein. These crops contain high amounts of protein, macro and micronutrients (Ca, P, K, Fe and Zn), vitamins, fibre and carbohydrates for balanced nutrition. They are rich in lysine and essential amino acids which are found only at low levels in cereal proteins (Mohmoud, 2009). Black gram (*V. mungo)* is an important food legume widely consumed in India. It also plays an important role in sustainable agriculture enriching the soil through biological nitrogen fixation. It is mostly grown in Madhya Pradesh, Maharashtra, Tamil Nadu, Uttar Pradesh, Rajasthan and Gujarat during rainy season, where as in Andhra Pradesh and West Bengal in winter (rabi) season (Ram *et al.,* 2010). On account of its short duration, photosensitivity and dense crop canopy it assumes special significance in crop intensification, diversification and conservation of natural resources and sustainability of production system (Katiyar and Dixit, 2010). In the recent past CSKHPKV came up with worthwhile production technologies. However, such technological benefits are not yet harnessed by the state farmers.

Therefore, yield level at farmers field is quite low than that is achieved in experimental farms and demonstration plots. Therefore, the present investigation was carried out to estimate the yield gaps in black gram for having planning for better research and extension.

Material and Methods

Improved technology package (Table 1) was compared with farmers' practice of growing mash in all the three blocks of Bilaspur district during *kharif* 2006-2009. In total, 120 trials were conducted on the farmer's field. The gross plot size was 400 m^2. Yield data for the improved practice as well as from farmers' practice were recorded at the time of threshing and analyzed to draw the inferences. The season-wise detail of sowing and harvesting has been given in Table 2.

The technology gap, extension gap and technology index were estimated using the following formulae (Kadian *et al*., 1997, Samui *et al*., 2000 and Dwivedi *et al*., 2014):

Technology gap = Potential yield (P) – Demonstration plot yield (D)

Extension gap = Demonstration plot yield – Farmer's plot yield

Technology index (%) = $\frac{(P - D)}{Pi} \times 100$

The potential yield refers to that maximum reported at the time of release of the variety. Cost of cultivation of black gram (*V. mungo)* includes cost of inputs like seed, fertilizers, pesticides etc. purchased by the farmers (in farmers practice) and supplied to him (in improved practice) as well as hired labour, sowing charges by bullocks/tractor and post harvest operation charges paid by the farmers. The farmers' family labour was not taken into consideration in the present study. The gross and net returns were worked out accordingly by taking cost of cultivation and price of grain and byproduct. Additional costs include expenditure on improved technological inputs over farmers' practice. Similarly, the incremental benefit-cost ratio (IBCR) was worked out as a ratio of additional net returns and corresponding additional cost of cultivation (Kumari *et al.*, 2007).

The seasonal water use (Et) was computed from profile water contribution (CS), effective rainfall (ER) and irrigation water applied (I) using the equation: Et = CS + ER + I. Since, the trials were conducted in wide area under varying agro-ecological conditions, the profile water contribution (CS) was not taken into consideration. Similarly, the crops were grown under rainfed farming conditions only. Thus, effective rainfall was considered as seasonal water use in the present study by taking into account the respective crop growth period of each demonstration and the water use efficiency was worked out accordingly (Table 2). The rainfall data were taken from 'Agro-meteorological Observatory' of Pulse Research Sub Station, Berthin Distt. Bilaspur (H.P.) which is situated in the centre of the district.

Results and Discussion

Grain yield

With the adoption of improved production technology on black gram (*V. mungo),* the grain yield was invariably higher (791 to 998 kg ha^{-1}) than the farmers' plot (510 to 590 kg ha^{-1}) yields during all the years (Table 4) which may be attributed to the adoption of recommended agro-technologies during the study period. Sagar and Chandra (2004) and Choudhary *et al.* (2009) have also reported increase in yield by the use of recommended agro techniques.

Table 4 revealed that percent seed yield increase in black gram in improved package over farmers' plots was highest (81.6%) during *kharif* 2006 and lowest (34.1 %) during *kharif* 2009. This indicates that with the adoption of improved technology in pulses, the yield levels in pulses could be raised by 34.1 to 81.6% over the farmers' practice. The yield advantage of 36.9 to 192.0% has also been reported in earlier studies (Kumari *et al*., 2007 and Choudhary *et al.*, 2009).

Table 1. Detail of improved package and farmers practice

Particulars	Improved package	Farmers practices (Local check)
Variety	UG-218	Local (Kathu)
Seed rate	18-20 kg/ha	30 kg/ha
Sowing method	Line sowing (30 cm x10 cm)	Broad casting
Situation	Rainfed	Rainfed
Fertilizer dose	20:40:20 (N:P:K kg/ha)	Nil
Plant protection	Need based insecticides & fungicides spray	No spray and insecticides & fungicides

Table 2. Date of sowing and harvesting

Year	Dates of sowing	Dates of harvesting
2006	25 June-07 July, 2006	22-05 October, 2006
2007	25 June-07 July, 2007	24-10 October, 2007
2008	24 June-07 July, 2008	25-10 October, 2008
2009	22 June-010 July, 2009	23-08 October, 2009

Technological gaps

The yield gaps in the present study were categorized into technological and extension gaps. The technology gap observed ranges from 202 to 409 kg ha^{-1} during the years of investigation. The highest technological gap was obtained during *kharif* 2009 (409 kg ha^{-1}) followed by 345 kg ha^{-1} during *kharif* 2008 while lowest gap was observed during *kharif* 2006 (202 kg ha^{-1}). This may be attributed to the lack of irrigation facilities, improper distribution of rainfall (Table 3), variation in soil fertility status, cultivation in the marginal lands, non congenial weather conditions and local specific crop management problems faced in order to obtain the yield potential of specific crop cultivars (Sagar and Chandra 2004; Choudhry 2013). The location specific crop management is required to bridge the gap in the potential and the demonstration yields (Kumari *et al.* 2007), besides strengthening of irrigation infrastructure in the region (Choudhry *et al.* 2009).

Extension gaps

The successful development, dissemination and adoption of improved technologies for small-holders depend on more than careful planning of research and the use of appropriate methodologies in extension. (Mishra *et al.* 2007; Choudhary 2013). The extension gap ranged from 201 to 448 kg ha^{-1} during the period of study. The higher extension gap in the present study (Table 4) indicates that there is strong need to aware and motivate the farmers which is emphasizing on need to educate farmers through various means for adoption of improved agricultural production technologies over existing local practices to minimize the extension gap. Maximum extension gap of 448 kg/ha was observed during *kharif* 2006 and lowest during 2009. Extension yield gaps are the indicators of lack of awareness for the adoption of improved farm technologies by the farmers (Kadian *et al.* 1997; Kumari *et al*. 2007; Choudhary 2013). Thus this study infers that extension functionaries of Bilaspur district have to strictly focus on dissemination of proven farm technologies in pulse production systems enhancing thereby the pulse productivity over existing.

Technology index

Black gram is the major component of existing pulse production systems in the Bilaspur district in terms acreage and production (Anonymous 2009) and is under cultivation with the farmers as pure or mixed crop since many years**.** Technology index indicates the feasibility of the evolved technology in the farmers' fields under existing agro climatic variations (Kumari *et al.* 2007; Choudhary *et al.* 2013). Lower the value of technology index, higher is

Table 3. Rainfall (mm) during the cropping season

Month	Year			
	2006	2007	2008	2009
July	289.0	387.4	246.2	399.4
August	380.0	390.2	375.6	340.6
September	198.8	17.2	64.6	172.6
October	27.6	2.0	22.6	4.0
Total	895.4	796.8	709	916.6

the feasibility of the improved technology. Technology index varied from 16.8 to 34.1% in different years of study. The lowest technology index 16.8% was recorded during *kharif* 2006 followed in increasing order by 25.8% during 2008, 30.4% during 2007 and 34.1% during *kharif* 2009, respectively. This indicate that a strong gap exist between the generated technology at the research institution and disseminated at the farmer`s field (Kadian *et al*. 1997, Vaghasia *et al*. 2005 and Kumari *et al*. 2007). But the introduction of HYV's and demonstration of improved technology followed by intensive awareness campaign will eventually lead to adoption of generated technology among farmers of the district to accelerate the crop diversification, crop intensification and productivity enhancement in the black gram (*V. mungo)*.

Economic analysis

The gross and net returns in improved practice were highest during kharif 2006 with an average value of INR 39920 and INR 31670/ha, respectively. While, in farmer practice highest gross and net returns recorded were INR 29500/- and INR 18000/-, repectively. The IBCR ranges from 3.10 to 4.64 (Table 5). Enhanced monetary returns as well as IBCR through improved farm technology have also been reported by various workers (Kumari *et al*., 2007; Choudhry *et al.* 2009; Choudhary *et al.* 2013). Overall economic analysis highlights that use of improved technology and its adoption in black gram (*V. mungo)* had substantially enhanced the farm gains over farmer's practice which indicated that use of farm technology can greatly improve the livelihood and profitability of the farming community of Bilaspur district.

Water use and water use efficiency

The total seasonal water use during the crop growth period in black gram (*V. mungo)* varied from 709.0 to 916.6 mm (Table 4). Water use efficiency (WUE) varied from 0.86 to 1.21 kg ha-mm^{-1} in the improved practice and 0.61 to 0.77 kg ha^{-1} mm in farmers plots. From the data, it was evident that use of improved technology has greatly enhanced the water use efficiency of black gram (*V. mungo)* as compared to farmers' field plots, though the crop water use was same under both the conditions (Table 3). This can be attributed to improved crop yields of black gram (*V. mungo)* in the improved practice because of better crop management and plant nutrition (Choudhary *et al.* 2006; 2009), resulting in higher water use efficiency with the same amount of seasonal water use. Overall, water use efficiency in improved plot was higher than that of farmer's plots.

Table 4. Yield of black gram affected by improved practices over farmer practice

Year (Kharif)	No. of trials	Yield (kg/ha)		LSD (P-0.05)	Technology gap (kg ha^{-1})	Extension gap (kg ha^{-1})	Technology index (%)	Seasonal water use (mm)	WUE (Kg ha^{-1}mm^{-1})	
		IP	FP						IP	FP
2006	21	998	550	19.1	202	448	16.8	895.4	1.11	0.61
2007	42	835	510	21.0	365	325	30.4	796.8	1.05	0.64
2008	30	855	546	32.4	345	309	25.8	709.0	1.21	0.77
2009	27	791	590	46.4	409	201	34.1	916.6	0.86	0.64
Average		869	549		189	321	26.7			

IP- Improved practice and FP-Farmer Practice

It can be concluded from the study that the wide gap between potential and demonstration yield in black gram (*V. mungo)* was mainly due to technological and extension gaps. The productivity and profitability of the agricultural farm can be improved greatly under rainfed situations by adopting the improved agricultural technologies in the Bilaspur district. It was also observed that there was need to educate and motivate the farmers for adoption of improved technologies, so that marginal farmer with limited resources could improve their livelihood and diversify their farming situation.

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Table 5: Cost of cultivation, Gross return, Net return and B: C ratio of improved practices over farmer practice

Year (Kharif)	Cost of cultivation (INR)		Gross return (INR)		Net return (INR)		Additional cost (INR)	Additional net return (INR)	IBCR*
	IP	FP	IP	FP	IP	FP			
2006	8250	5070	39920	22000	31670	16930	3180	14740	4.64
2007	11572	8520	33400	20400	21828	11880	3052	9948	3.26
2008	13890	10500	38475	24570	24585	14070	3390	10500	3.10
2009	13890	11500	39550	29500	25660	18000	2390	7660	3.21
Average	11900.5	8897.5	37836.3	23161.3	25935.8	15220	3003	10715	3.55

IBCR-Incremental Benefit Cost Ratio

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Response and quantification of certain milk attributes following artificial induction of lactation in Jersey crossbred cows of Himachal Pradesh

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Abstract

The present study evaluated the efficacy, lactation response, certain attributes of the milk induced and plasma alongwith reproductive changes periodically from day 5 to 75 using a 13 day protocol (day of first injection as day 1) of diethylstilbestrol, hydroxyprogesterone caproate and dexamethasone. A total of 22 non-lactating and infertile/sterile Jersey crossbred cows (G1=19, in goshalas; G2=3, with individual farmers) were used. In addition, normal postpartum cows (C=5) were also used to compare normal and induced milk. The overall efficacy of the protocol was 31.8% (21% in G1; 100% in G2). The milk yield at all recordings (five) was significantly higher in G2 than G1, the average being 1.0 and 3.6 L/d, respectively. Except for low milk Ca, especially in G1, comparable Na, K and Mg, declining estrogen and IGF-1 (Insulin-like Growth Factor-1) by day 30-35 and normal specific gravity and fat percentage at different evaluation intervals (two to six) in the induced milk suggested it to be safe for consumption after one month of induction. There was a significant correlation in Ca and Mg concentrations between blood *versus* milk as well as with increase in milk quantity at different days of lactation in the induced cows. Further, 2 of the 3 G2 chronic repeat breeder cows became pregnant. Higher BCS in G2 *versus* G1 (3.3 ± 0.1 *versus* 2.7 ± 0.14) was the probable reason for superior efficacy, better lactation response and setting up of pregnancy in G2.

Key words: Cows, Induction of lactation, Diethylstilbestrol, Progesterone

Artificial induction of lactation revitalizes the production potential of the infertile/sterile and unproductive cattle. Earlier, estradiol-17β has been used in Indian cattle (Chakravarty *et al*. 1981a; Deshmukh *et al*. 1992; Mohan *et al*. 2010) other than Jersey, the mainstay breed of Himachal and other hilly Indian terrains. However, breed variation in lactation response (Jewell 2002) and minerals in milk (Chauhan 1999) underscores the need for systematic studies *per se* using easily accessible estrogen derivative. Further, induced milk becomes a concern, as dietary/milk estrogen increases the incidence of breast and genital cancers (Ganmaa and Sato 2005). Milk insulin-like growth factor-1 (IGF-1), not reported in Indian studies, may resist pasteurization and cross the intestines undigested to increase the propensity of colon, breast or prostate cancers (Epstein and Samuel 1990) in humans. Hence, with a holistic intent, the present study evaluated the response and milk quality in Jersey crossbred cows injected diethylstilbestrol, progesterone and dexamethasone.

Materials and Methods

The cattle selected were Jersey crossbreds (cows and heifers, unto 62.5% exotic germplasm) and were non-lactating, non-pregnant with adequately developed teats and udder. The cows belonged to gaushalas [G1; n=19] or individual farmers [G2; n=3]. A group of normal postpartum cows from the University Dairy Farm, at lactation stage corresponding to the induced cows (non-lactating), was kept as control [C; n=5]. The G1 cows were provided roughages with little or no concentrate which, however, was given in variable amounts to G2. One week prior to induction, the cows were given a dose of Albendazole (15 mg/kg Analgon; 1500 mg / bolus; Vetoquinol Indian Animal Health Limited, Mumbai) and provided 1.5 kg concentrates and 30 g mineral mixture during induction (13 days).

Before induction, BCS (Edmonson *et al*. 1989), live weight and reproductive status (recorded every 15 day interval) by transrectal palpation was recorded. The protocol was

initiated during the luteal phase and comprised of intramuscular injections of diethylstilbesterol (Miss-Mating Veterinary; 10 mg/ml; Inmac Laboratories, Bangsipura, Punjab) - 0.07 mg/kg of b. wt.; hydroxyprogesterone caproate (P-Depot; 250 mg/ml; Sarabhai Zydus, Ahmedabad) - 0.2 mg/kg of b. wt. from day 1 to 10 and dexamethasone sodium phosphate (Dexagee; 4 mg/ml; German Remedies, Mumbai) - 14 mg/d from day 11 to 13. The day of first injection was day 1. All the cows were given 30g Galog (Indian Herbs, Saharanpur) orally for two weeks from day 1. Stripping of teats and udder massage began from day 5. The induction was considered successful in cows producing 1Litre or more milk/d during the investigation period of 75 day. The day of appearance of udder secretions, initiation of lactation and milk quantity (L/d) at different days (day 15, 30, 45, 60 and 75) was recorded.

Estimations of Na, K (flame photometry; Systronics Flame Photometer 129), Ca and Mg (Atomic Absorption Spectrophotometer; Perkin Elmer Analyst, 400) in blood plasma and milk (day 5, 15, 30, 35, 50, 75); total estrogen and progesterone in skim milk (day 15, 30, 50, 75) and IGF -1 in plasma and skim milk (day 5, 35) (ELISA; standard kits using DRG Instruments GmbH, Germany) were undertaken. The analytical sensitivity, the inter- and intra-assay coefficient of variation of estrogen was 9.714 pg/ml, 7.39% and 4.01%, respectively. The corresponding values for progesterone were 0.045 ng/ml, 6.63% and 5.7% and for IGF-1 were 1.29 ng/ml, 7.45% and 5.63%, respectively. The milk specific gravity (lactometer) and fat content (Gerber's method) were evaluated in day 15, 30 and 45 samples. The data were analyzed using Tukey-Kramer multiple comparison test of ANOVA or Student's t – test. A difference of $P<0.05$ (at least) was considered as significant, whereas $P=0.10$ was a tendency for difference. The entire statistical analysis was performed using SAS® (Statistical Analysis System).

Results and Discussion

Induction of lactation was successful in 21% G1 (4/19 cows) and all the cows in G2 (3/3 cows), the overall success being 31.8%. Using similar drugs, a much higher success of 82-100% in exotic (Sawyer *et al*.1986; Ryan *et al*. 1988) and a much lower success of 53% in Indian crossbreds (Chakravarty *et al*. 1981a) was reported. There was no difference in G1 *versus* G2 on the day of appearance of watery/honey like secretions (4.2 ± 0.2 *versus* 6.6 ± 1.8) and initiation of lactation (10.0 ± 1.7 *versus* 12.3 ± 1.4). Using a similar protocol, lactation was initiated between 9 to 14 days (Chakravarty *et al.* 1981b). The milk yield increased gradually and was higher ($P<0.05$) in G2 *versus* G1 at days 15 (0.5 ± 0.0 *versus* 0.2 ± 0.0 L), 30 (2.9 ± 0.2 *versus* 0.6 ± 0.1 L), 45 (4.5 ± 1.0 *versus* 1.1 ± 0.1 L), 60 (4.9 ± 1.0 *versus* 1.5 ± 0.1 L) and 75 (5.2 ± 1.5 *versus* 1.4 ± 0.1 L). Higher live weight and BCS in G2 *versus* G1, 346.7 ± 14.5 kg *versus* 269.0 ± 30.3 Kg and 3.3 ± 0.1 *versus* 2.7 ± 0.14,) respectively, could be the reason for difference in lactation response and induction failures in cows from goshalas that had lower live weight (259.46 ± 9.9 kg) and BCS (2.6 ± 0.2). The average yield for all the days in present study was 1.0 L/d in G1 and 3.6 L/d in G2, respectively. Much higher average of 7.83 L/d (Sawyer *et al*. 1986) and 5-6 L/d (Chakravarty *et al*. 1981a; Sawyer *et al*. 1986; Ryan *et al*. 1988) has been reported which may be due to an inherent potential of high yield. The peak milk yield in G1 (1.42 ± 0.15 L at day 60) was less than G2 (5.20 ± 1.50 L at day75). In the Indian crossbreds, a peak of 5.51 L at 21 weeks (Chakravarty *et al*. 1981a) and of 4.5 L at day 31 (Agrawal *et al*. 1993) have been reported.

The plasma Na concentration did not differ much either within or between groups and was comparable to normal range of 132 to 152 mEq/L (Kaneko 1989). The milk Na (range: 15.7 ± 2.1 to 23.1 ± 1.2 mEq/L) resembled more closely to Jersey (20.4 ± 0.4 mEq/L) than Jersey x Red Sindhi crossbreds (22.0 ± 0.4 mEq/L) (Chauhan 1999). Slightly higher milk K of 3.9 to 5.8 mEq/L (Kaneko 1989) and 4.97 to 5.07 mEq/L from early to mid lactation (Manzoor *et al.* 1994) has been reported. Milk is an intracellular fluid and therefore contains large amount of K compared to plasma (Schmidt 1971), which was evident in present study for most lactation days. Compared to C, the milk K in G1 and G2 was comparatively higher for nearly all lactation days, which augurs well with higher milk potassium in low producing cows (Harrison *et al.* 2007). The average milk yield in C group (6.62 ± 0.52 L/d to 7.10 ± 0.53 L/d from day 15 to day 75) was higher than G1 and G2 ($P<0.01$). Much higher milk K concentrations of 34.1 to 47.2 mEq/L (Manzoor *et al.* 1994), 31.8 ± 0.6 mEq/L in early lactation to 26.5 ± 0.8 mEq/L in later lactation (Chauhan 1999) have been reported. Variation among different studies could be due to difference in dietary K (Harrison *et al.* 2007). The plasma Ca in C, varyingly higher than G2 and G1 at most lactation days, was close to 97 to 124 mg/L in exotic cows (Kaneko 1989), but much higher than 12.4 ± 0.2 mg/dL (Hadzimusic and Krnic 2012). Plasma like trend was recorded in milk Ca with highest and lowest values in C and G1 leading to most of the significant differences. The Ca in milk comes from the blood Ca, which is derived from the feed and from the skeleton (Schmidt 1971). Hence,

Table 1. Average (Mean ± S.E.M) concentrations of Na (mEq/L), K (mEq/L), Ca (mg/L) and Mg (mg/L) in blood plasma and milk at different days of lactation in C (n=5), G1 (n=4) and G2 (n=3)

Mineral	Group	Plasma						Milk					
		Day of lactation						Day of lactation					
		5	15	30	35	50	75	5	15	30	35	50	75
Na	C	131.6 ±2.3	133.6±3.8	126.8±0.4	126.0±0.8	124.8±1.8	128.0±1.1	17.3±2.7	17.4±4.1	16.9±0.4^{1}	16.8±0.7^{5}	16.6±1.7	18.1±4.0
	G1	115.5±3.8	107.5±11.6	99.5±6.7	87.5±10.5	99.0±5.3	84.5±15.7	23.1±1.2^{b,2}	19.8±2.3	15.7±2.1	19.0±3.4	18.1±0.3^{a}	20.3±0.9
	G2	129.0±1.7	135.3±3.5	127.3±2.4	136.6±4.3	131.6±2.0	122.6±7.3	15.7±2.2^{a,1}	18.2±3.0	21.9±1.1^{2}	20.2±0.0^{6}	19.7±1.3	21.4±0.2^{b}
K	C	2.9±0.1^{4}	2.8±0.1	2.7±0.1	2.6±0.2	2.5±0.2	2.7±0.2	2.9±0.1^{5}	2.8±0.2^{5}	2.8±0.1^{i,5}	2.7±0.2^{5}	2.6±0.1^{5}	2.9±0.1^{5}
	G1	3.5±0.3^{2}	3.2±0.3	2.9±0.1	2.5±0.3	2.8±0.2	2.4±0.7	5.1±0.3^{6}	8.8±4.5	6.6±0.7^{6}	6.3±0.5^{6,7}	5.6±1.0^{6,7}	3.0±1.1^{5}
	G2	2.4±0.1^{e,1,3}	3.1±0.0^{f,h}	2.8±0.0^{f,h}	3.1±0.0^{f,h}	3.8±0.7	2.5±0.0^{g}	8.5±2.7^{a,c}	10.5±1.2^{c,e,6}	16.8±6.6^{2}	13.2±2.1^{6,8}	16.7±0.4^{d,6,8}	18.7±2.1^{b,f,6}
Ca	C	80.6±4.8	90.1±3.1^{6}	93.0±11.0^{2}	82.5±2.4^{6}	85.1±2.5^{6}	89.7±3.7^{2,6}	57.5±3.2^{6}	67.3±6.6^{6}	71.6±4.8^{6}	67.7±7.1^{6}	67.7±10.8^{6}	61.8±6.2^{2}
	G1	67.4±3.5^{f}	51.8±8.0^{5}	52.0±4.1^{1}	40.6±2.0^{5}	36.1±5.0^{e,5}	30.4±6.8^{e,5}	9.2±0.3^{b,e,g,5}	4.7±1.2^{a,e,g,5}	12.5±2.3^{b,g,5}	16.9±0.9^{f,g,5}	11.0±3.5^{g,5}	42.1±1.0^{h,1,5}
	G2	71.0±9.3	63.9±0.4^{5}	72.7±9.6	55.9±5.3^{5}	47.0±10.2^{5}	49.7±12.7^{1}	105.3±32.6^{6}	68.2±14.0^{6}	54.8±21.5	73.6±12.5	57.4±7.3^{6}	66.5±5.9^{6}
Mg	C	18.2±0.8^{2}	21.3±1.2^{2}	21.7±3.0^{2}	18.0±2.0^{6}	20.4±2.2^{6}	21.8±3.2^{6}	7.3±0.4^{6}	7.1±0.2^{6}	6.7±0.5	7.1±0.4	7.5±0.4	6.8±0.0
	G1	12.3±1.5^{b,1}	9.9±2.3^{1}	8.7±1.3^{a,1}	6.4±0.8^{a,1,5}	7.0±0.6^{a,1,5}	5.8±1.7^{a,5}	2.0±0.9^{5}	1.6±0.3^{5}	3.1±1.7	3.8±1.2	4.9±0.7	5.1±0.8
	G2	16.7±3.4	17.4±4.1	18.1±2.6^{2}	12.3±2.1^{2}	10.8±1.8^{2}	9.7±1.7^{5}	9.7±3.4^{6}	11.8±7.1	7.3±3.1	8.4±3.1	7.7±4.6	9.0±5.3

Values with different superscripts differed significantly ($^{ab,\ cd}$ within same row and $^{12,\ 34}$ within same column at P<0.05; $^{ef,\ gh}$ within same row and ^{56,78} within same column at P<0.01) for each mineral in plasma or milk

consistently lower milk Ca in G1 compared to the G2 confirms a better nutritional status in the latter. The average milk Ca concentration ranged from 120.8 ± 2.6 mg/dl to 130.7 ± 2.5 mg/dl without much effect of breed and stage of lactation (Sen *et al.* 1989, Chauhan 1999). The plasma Mg, barring day 5, remained consistently lower in G1 and differed significantly from C and G2 at most days. The correlation of each mineral between plasma *versus* milk concentration and milk concentrations *versus* milk quantity in the induced cows, at different days of lactation, revealed significance for Ca and Mg. This implies (i) transfer of Ca and Mg from plasma to milk and (ii) sustained increase in milk Ca and Mg concentration with the increase in milk quantity and is in complete agreement with Nozad *et al*. (2012) recording a significant (P<0.01) positive correlation between the blood and milk parameters for Ca and Mg but not for Na and K.

Gradual decline in milk estrogen with progression of lactation in all groups of present study corroborated to 180 ± 73 pg/ml at d 15, reducing to 95 ± 32 pg/ml at d 42 (Erb *et al*. 1976). Relatively higher estradiol concentrations of 430 pg/ml and 330 pg/ml at day 16 and 32, respectively, have also been reported (Harness *et al*. 1978). In Indian cattle, estrogen concentration in induced than postpartum milk have been relatively higher (210.0 ± 50.0 versus 170.0 ± 20.0 pg/ml) (Narendran *et al*. 1979) or similar (59.1 pg/ml *versus* 54.7 pg/ml) (Mohan *et al*. 2010). In contrast, the postpartum milk had 30-80 pg/ml of estrogen that was undetectable in induced milk (Agrawal *et al*. 1993). Except for higher milk progesterone at day 15 in G1, it did not vary among different groups. Noticeably, milk progesterone in C was lower than induced cows (Table 2). The 15 day progesterone values simulated to a previous study, significantly higher progesterone in induced (1.5 ± 0.0 ng/ml) than normal (1.3 ± 0.0 ng/ml) milk (Mohan *et al*. 2010) as against nearly similar concentration of 2ng/ml from day 5 to day 30 in induced milk has been reported (Agrawal *et al*. 1993). In contrast, induced cows had relatively higher progesterone at day 15 (5.1 ± 1.2 ng/ml) and 42 (3.9 ± 1.5 ng/ml) (Erb *et al*. 1976) and still higher average of 15.1 ± 6.2 ng/ml to 18.1 ± 2.2 ng/ml over a 30 day period (Harness *et al*. 1978; Zhou *et al*. 2009). Hence, a precipitous decline in milk estrogen and IGF-1 by day 30-35 makes the induced milk to be safe for human consumption one month after induction. The available literature focusing exclusively on estrogen content indicate the induced milk to be safer for consumption after 2 to 3 weeks of induction (Mohan *et al*. 2010). Variation in estrogen and progesterone concentration in the induced milk among different studies may be attributed to differences in the molecules used *per se* (Harness *et al*. 1978), method of estimation (Narendran *et al*. 1979), duration of treatment (Deshmukh *et al*. 1993), endogenous contribution (Sawyer *et al*.1986), vehicles used, interval between two injections (Harness *et al*. 1978) and quantity of milk produced (Sawyer

Table 2. Average (Mean ± S.E.M) milk estrogen (pg/ml), progesterone (ng/ml) and IGF-1 (ng/ml) at different days of lactation in C (n=5), G1 (n=4) and G2 (n=3)

Hormone	Group	Day of lactation			
		Milk			
		15	30	50	75
Estrogen	C	233.8 ± 18.6^{b}	114.2 ± 25.0^{a}	99.0 ± 18.8	103.8 ± 63.6
	G1	311.5 ± 82.7^{b}	81.7 ± 31.5^{a5}	84.3 ± 36.6	121.0 ± 52.4
	G2	169.6 ± 41.9	354.3 ± 55.6^{f,6}	109.0 ± 5.6^{e,h}	51.6 ± 14.2^{g}
Progesterone	C	0.9 ± 0.02^{a}	0.8 ± 0.01	1.0 ± 0.1	0.8 ± 0.03
	G1	3.1 ± 0.5^{b}	1.8 ± 0.6	1.7 ± 0.6	1.7 ± 0.5
	G2	1.0 ± 0.12^{a}	1.0 ± 0 .02	1.7 ± 0.2	1.7 ± 0.3
		Day of lactation			
		Plasma		Milk	
		5	**35**	**5**	**35**
IGF-1	C	87.8 ± 22.4	67.8 ± 14.0	155.0 ± 3.6^{1}	101.4 ± 23.4
	G1	87.3 ± 20.1	98.5 ± 19.0	190.1 ± 10.1^{b,2}	142.0 ± 8.7^{a}
	G2	44.7 ± 31.6	97.0 ± 28.0	144.0 ± 3.12^{a}	112.6 ± 25.0

Values with different superscripts differed significantly (^{a,b} within same row and ^{1,2} within same column at P<0.05; $^{e,f,\ g,h}$ within same row at P<0.01)

*et al.*1986). The later factor appears to be of great significance as estrogen and progesterone in milk of induced cows were approximately twice as concentrated as in the normal post-partum milk (Harness *et al*. 1978; Deshmukh *et al*. 1993). The plasma IGF-1 concentrations in different groups did not differ, whereas the milk IGF-1 at day 5 was varyingly higher than the day 35 concentrations in all the groups (Table 2). The IGF-1 is a tissue mitogen and increases the number of milk secreting units (Schmidt 1971). Higher IGF-1 in milk than plasma is a testimony of its localized production in mammary tissue (Epstein and Samuel 1990).

The average fat percentage (range: 3.5 ±0.7 to 5.1±0.7) and specific gravity (range: 1.02±0.02 to 1.03±0.02) that depends on the amount of fat in milk, did not differ within and between groups at different days, which is an affirmation to earlier report (Deshmukh *et al.*1993). The induction protocol did not affect reproduction in any of the cows unlike aberrant estrus activity (Chakravarty and Razdan 1981) or ovarian cysts (Sawyer *et al*.1986) recorded earlier. Two cows of G2, however, became pregnant 90 to 120 days after the initiation of the treatment.

In conclusion, a moderate efficacy, normal milk quality and no aberrant reproductive change following induction by diethylstilbestrol, hydroxyprogesterone caproate and dexamethasone makes it a suitable preposition for use in unproductive and infertile cattle. However, a better body condition dictates a favorable outcome. Though there was precipitous decline in milk estrogen and IGF-1 by day 30-35, the use of induced milk after one month be recommended with caution.

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Socioeconomic factors affecting vegetable production in Kullu district of Himachal Pradesh

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Abstract

The present study was based on primary data collected from a representative sample of 60 vegetable growers in Kullu District of Himachal Pradesh in order to examine the relationship of some socio-economic variables with productivity of selected vegetables. The study revealed that the female headed families were obtaining 10 to 18% higher productivities than male headed in case of cucumber, cauliflower, cabbage and pea. Families having size of more than 4 persons were obtaining higher yields in case of cauliflower, cabbage, tomato, Iceberg and cucumber. Further, higher yields in most of the vegetable crops were obtained by those households whose heads were in the age group of greater than 30 years. The educational-level of the head of the sample households was found to have a direct relationship with the productivity of all the vegetable crops. The marginal and small farmers were getting higher yield in vegetables than the farmers having more than 2 hectares of land. Regression analysis revealed that 1% increase in the area under crop would increase gross income of the farmers by 1.21% in case of pea crop. The study emphasized that the rural unemployed youth with education upto graduation should be encouraged to engage themselves in vegetable production as a profession.

Key words: Socio-economic factors, productivity, regression analysis, marginal value productivities (MVPs)

Vegetables play a pivotal role in Indian agriculture by providing food, nutritional and economic security to the people of India with higher returns per unit area to the producers. In addition, vegetable crops have higher productivity and shorter maturity cycle, which leads to higher returns per unit area and time. Worldwide, India holds the second position by contributing 15.70 and 14.50% to global vegetable area and production, respectively. In our country, vegetable production is threatened by fragmentation of land, climate change, decreasing natural resources and uneven growth across the country. In Himachal Pradesh, 90% of the population live in rural areas and depend on agriculture for their livelihoods. The agricultural sector of Himachal Pradesh has adopted a diversification approach that demands to focus on the vegetable production including potato. Himachal Pradesh has earned much reputation by producing tomato, cauliflower, cabbage, capsicum, cucumber, pea, brinjal, radish, carrot and other vegetables. The farmers of the state focus more upon generating the cash crops for more revenue earning as these suit the agro-climatic conditions of the state. Shimla, Sirmaur, Solan, Kangra, Mandi and Kullu are the main districts producing vegetables. The strategy to reduce poverty in the state is impossible without significant increase in yield of different vegetable crops. In addition to land and expenses on various farm inputs, the quality and productivity of vegetables depend upon the adoption of latest technology. There are several worthwhile technologies, but farmers have not yet succeeded in taking full advantage of these. Further, various social and economic factors like land holding, available livestock, education-level and family size play a significant role in the adoption of modern technologies in agriculture. Therefore, the present study has been undertaken to examine the affect of these social and economic factors in the vegetable production and factors affecting resource use efficiency in Kullu District of Himachal Pradesh.

Materials and Methods

The study was based on primary data collected from a representative sample of 60 vegetable growers in Kullu District of Himachal Pradesh on well prepared pre-tested schedule by personal interview method for agricultural year 2011-12. Three-stage sampling technique was used to select vegetable growers in the study area. In the first stage, two blocks *viz.* Kullu and Naggar were selected purposely out of five blocks of Kullu District because of their potential to grow vegetable crops. In the second stage, 3 villages *viz.* Kalehali, Jia and Hurla in Kullu Block and 3 villages *viz.* Seobagh, Bari and Nashala in Naggar Block were selected randomly thereby making a total sample of six villages. In the third stage of sampling, 10 vegetable growers from each of the 6 villages were selected randomly to draw a representative sample of 60 vegetable growers. The following type of Cobb-Douglas production function was employed to examine the input-output relationship in vegetables grown on sample farms:

$$Y = a\, X_1^{b1}\, X_2^{b2}\, X_3^{b3}\, e^{U}$$

In natural log form:

$$\text{Ln } Y = \text{Ln } a + b_1 \text{Ln } X_1 + b_2 \text{Ln } X_2 + b_3 \text{Ln } X_3 + U$$

Where,

Y = Total income from different vegetables (INR per bigha i.e. 0.08 ha)

a = Constant term (efficiency parameter)

X_1 = Area under crop (Bigha per farm)

X_2 = Livestock (Number per farm)

X_3 = Working capital i.e. expenditure on planting materials, fertilizers, FYM, insecticides, fungicides, bullock/power-tiller/tractor, human labour and irrigation (INR per farm)

b_1 to b_3 = Regression coefficients

U = error term

Results

Relationship of socio-economic factors on vegetable productivity

Socio-economic status of the farmers had a significant relationship with the productivity of different crops as it is an important indicator of mental attitude and socio -economic soundness of the farmers. Table 1 depicted the extent of relationship between the genders of head of sample household on productivity of different vegetables. The female headed families were obtaining 10 to 18% higher productivities than male headed in case of cucumber, cauliflower, cabbage and pea. In case of tomato crop, it was 90% higher. The higher productivity in case of most of the vegetables grown may be due to the preferred choice and active participation of females in view of employing themselves in their own enterprise. Further, several operations like sowing and interculture are performed by females with more devotion and efficiency than the males.

Table 1. Gender-wise relationship of head of sample households on productivity (t/ha) of different vegetables

Crop	Gender of the head of family	
	Male	Female
Cauliflower	23.29	25.79
Cabbage	22.05	26.04
Tomato	23.24	44.55
Iceberg (Lettuce)	18.55	8.34
Pea	7.24	8.58
Cucumber	28.84	23.93
Others*	14.11	7.78

*Broccoli, turnip, okra, carrot, brinjal, chilli, etc.

Families having strength of more than 4 persons were obtaining higher yields in case of Cauliflower (22%), cabbage (10%), tomato (40%), Iceberg (36%) and cucumber (30%), while in case of pea, it was found to be better managed by the small families having less than 4 family members because labour requirement in this particular crop is comparatively low as compared to other vegetable crops in the study area (Table 2).

Table 2. Relationship of total family members on productivity (t/ha) of different vegetables

Crop	Family members (Number)		
	< 4	5 to 7	> 7
Cauliflower	20.80	25.45	26.04
Cabbage	20.69	22.79	26.66
Tomato	21.30	29.90	29.31
Iceberg (Lettuce)	8.91	29.16	16.66
Pea	8.34	7.23	7.09
Cucumber	28.60	37.50	21.00
Others*	7.81	16.70	17.28

*Broccoli, turnip, okra, carrot, brinjal, chilli, etc.

Higher yields in most of the vegetable crops were obtained by those households whose heads were greater than 30 years of age (Table 3). This may be due to the experience of the farmers. Further, the heads in age group between 30 to 45 years were found to manage their crops in a better manner as they were having dual characteristic

of experience and energy. Therefore, emphasis should be given on this particular group giving regular trainings in combination with the frequent exposure visits to the major vegetable growing areas of the state.

Table 3. Relationship of age of the head of sample households on productivity (t/ha) of different vegetables

Crop	Age-group (Years)		
	15 to 30	30 to 45	> 45
Cauliflower	23.73	25.78	21.60
Cabbage	25.00	24.28	20.45
Tomato	25.58	34.71	18.84
Iceberg (Lettuce)	25.00	17.68	23.75
Pea	6.00	7.81	8.25
Cucumber	25.00	26.50	28.19
Others*	12.83	13.59	13.93

*Broccoli, turnip, okra, carrot, brinjal, chilli, etc.

From the Table 4, it can be envisaged that the educational-level of the head of the sample households have a direct relationship with the productivity of all the vegetable crops. The productivity obtained by the literate groups with primary to plus 2 were higher than those either illiterate or having education as a graduate or post-graduate. This may be due to the reason that usually graduates go for service sector rather than employing themselves in agriculture, thus, making agriculture as a subsidiary source of income to them. While, illiterates were found to fall under old age group and usually follow traditional practices on the field due to the lack of knowledge regarding modern inputs. Therefore, there is a scope for employing and encouraging the farmers with at least primary education in their existing enterprises or providing them with the conditions required for getting higher returns through proper supply of critical farm inputs. This would ultimately help in reducing the extent of unemployment among rural youth and, hence poverty in the state.

The results in Table 5 revealed that marginal (<1 ha of land) and small (1 to 2 ha of land) farmers were getting higher yield in vegetables than those having more than 2 ha of land. This may be due to their sensitive and labour intensive nature, which needs proper care throughout the whole production process. Ease in management was found to be another reason for higher productivity on small and marginal farms. Scarcity of labour and increasing wages were also found to be the major constraints in profitable production of vegetables by large farmers.

Table 4. Relationship between education-level of the head of sample households and productivity (t/ha) of different vegetables

Crop	Education-level				
	Illiterate	Primary	Matric	Plus 2	Graduate
Cauliflower	25.18	26.08	25.16	26.16	19.23
Cabbage	25.00	25.29	25.00	23.23	17.25
Tomato	35.41	32.13	31.85	35.79	9.78
Iceberg (Lettuce)	NA	17.11	15.74	38.46	NA
Pea	6.25	8.13	7.14	8.50	7.50
Cucumber	NA	20.00	30.00	31.11	15.00
Others*	5.63	11.09	21.65	17.46	6.78

Table 5. Relationship of total land holdings on productivity (t/ha) of different vegetables

Crop	Land holding		
	< 1 ha	1 to 2 ha	> 2 ha
Cauliflower	25.75	27.95	18.51
Cabbage	24.00	22.41	19.83
Tomato	31.16	39.31	15.99
Iceberg (Lettuce)	15.19	20.00	NA
Pea	7.69	8.13	8.75
Cucumber	26.88	NA	NA
Others*	13.71	16.59	11.11

*Broccoli, turnip, okra, carrot, brinjal, chilli, etc.

Resource use efficiency in vegetable production

Table 6 depicted the results of Cobb-Douglas production function for different vegetable grown in the study area. The adjusted coefficient of multiple determination (R^2) for all the major crops grown except iceberg were found to be significant at 1% level of significance. It was observed to be 0.9591, 0.8024, 0.7081, 0.8420 and 0.8343 for cauliflower, cabbage, tomato, pea and cucumber indicating that the explanatory variables included in the regression analysis explains around 95, 80, 71, 84 and 83% of the total variation in the gross returns of the farmers through respective vegetables. The results of the regression analysis revealed that in most of the crops, the area under the crop was significantly affecting the gross returns of the farmers. The 1% increase in the area under crop would increase gross income of the farmers by 1.21%, 0.96%, 0.89%, 0.65% and 0.60% in case of pea, cabbage, cucumber, tomato and cauliflower, respectively. The regression coefficients were significant at 1% level for cabbage, cucumber, tomato and cauliflower while, in case of pea crop, the coefficient was significant at 5% level of significance. As far as the second factor of production (Number of livestock) is concerned, it was found to have positive significant influence on cucumber and cauliflower (1% level), which imply that the gross returns of farmers could be increased by 0.12% and 0.05% with the increase of 1 % livestock on sample farms. Working capital had also positive significant (1% level) impact on gross returns obtained from growing of cucumber, tomato and cauliflower. The value of production elasticities for cucumber (0.9952), tomato (0.6517) and cauliflower (0.2903) implied that 1% increase in the total working capital on mentioned crops would increase the gross returns of the farmers to about 1.00%, 0.65% and 0.29%, respectively.

Further, the returns to scale to the tune of 1.3055 and 1.2059 obtained in case of tomato and pea revealed that there would be more than 1% increase in the gross returns of the farmers if all the three factors of production will simultaneously be increased by 1% showing a condition of increasing returns to scale. It indicates that farmers are operating in first stage of production in these crops. However, in case of cabbage (0.9611) and cauliflower (0.9348), it shows diminishing returns to scale if all the factors of production will be increased by 1% indicating that there could be less than 1% increase in the gross returns from cabbage and cauliflower to the farmers of the study area. The results were found to be statistically significant at 1% level of significance. It indicated that farmers are operating in rational zone of the production function in these crops.

Table 6. Results of Cobb-Douglas production function

Variable			Crop					
			Cauliflower	Cabbage	Tomato	Iceberg	Pea	Cucumber
Constant term	Production elasticities	a	7.3665** (1.0502)	9.8088** (1.1090)	4.2484^{NS} (2.4159)	7.7153^{NS} (6.8702)	9.0154^{NS} (4.2035)	0.1473^{NS} (3.4726)
X_1 / Area under crop (Bigha per farm)		b_1	0.5955** (0.1247)	0.9611** (0.1199)	0.6538** (0.2342)	0.7647^{NS} (0.6133)	1.2059* (0.4907)	0.8866** (0.2763)
X_2/Livestock (Number per farm)		b_2	0.0490** (0.0158)	-0.0203^{NS} (0.0178)	-0.0314^{NS} (0.0257)	0.0233^{NS} (0.0479)	-0.0138^{NS} (0.0527)	0.1185** (0.0372)
X_3/Working capital (INR per farm)		b_3	0.2903* (0.1157)	-0.0056^{NS} (0.1210)	0.6517* (0.2571)	0.2665^{NS} (0.7222)	0.0242^{NS} (0.4717)	0.9952* (0.3812)
Adjusted coefficient of multiple determination (R^2)			0.9591**	0.8024**	0.7081**	0.7002^{NS}	0.8420**	0.8343**
Degree of freedom			40	36	37	6	7	7

Figures in the parentheses are the standard errors of regression coefficients; * Significant at 5% level of significance; ** Significant at 1 % level of significance; NS, Not significant

The marginal value productivities (MVPs) for area under cauliflower, cabbage, tomato and cucumber were significant at 1% level of significance while in case of pea, it was significant at 5% level (Table 7). The MVPs were found to be 24701.0, 15665.0, 14792.1, 10496.9 and 10110.1 for tomato, cabbage, pea, cauliflower and cucumber, respectively. It indicated that the addition of one bigha (0.08 ha) of land under above mentioned vegetables will increase the farmer's income by INR 24701, 15665, 14792, 10497 and 10110, respectively. This suggested that the farmers of the study area could increase their income to a significant amount by increasing the area under different vegetable crops. MVPs for number of livestock available on farms were computed to be 1084.5 and 743.1 for cauliflower and cucumber. It indicated that increase in one unit of livestock available will increase the farm income by INR 1084 and INR 743, respectively. The results were found to be positively significant at 1% level. These results suggested that farmers growing cauliflower and cucumber could also raise their income by addition of more animals to their available livestock which showed a complementary relationship with the respective crops. MVPs for working capital *i.e.* investment on seeds/seedlings, fertilizers, plant protection measures, labour, irrigation, etc. were positively significant at 5% level with values 2.27, 1.23 and 0.70 for tomato, cucumber and cauliflower crops, respectively. It indicated that an investment of INR 1 by the farmers for all the inputs used in production process will raise the farmer's income by INR 2.27, INR 1.23 and INR 0.70, respectively. As the one rupee investment in tomato and cucumber crops will increase the farmer's income by more than one rupee keeping all other factors constant at their geometric mean level. Therefore, the farmers of the study area were advised to make more investment on different farm inputs used in tomato and cucumber crops to fetch more returns.

It can be concluded from the above analysis that the families having family size of more than 4 persons headed by females with higher education level were obtaining higher yields in vegetable production. Furthermore, vegetable growers can increase their farm income by adding more area under vegetables; with additional number of livestock on their farm; and with the additional working capital expenditures on tomato and cucumber crops especially.

Table 7. Marginal value productivities of vegetables for different inputs in the study area

Variable	Crop					
	Cauliflower	Cabbage	Tomato	Iceberg	Pea	Cucumber
X_1/Area under crop (Bigha per farm)	10496.85** (2197.56)	15665.01** (1954.25)	24701.02** (8849.00)	20648.81 ^{NS} (16560.37)	14792.11* (6019.11)	10110.06** (3150.37)
X_2/Livestock (Number per farm)	1084.47** (350.94)	-142.86 ^{NS} (125.31)	-516.60 ^{NS} (422.69)	2749.82 ^{NS} (5660.72)	-71.70 ^{NS} (273.69)	743.11** (233.50)
X_3/Working capital (INR per farm)	0.70* (0.28)	-0.01 ^{NS} (0.24)	2.27* (0.89)	0.82 ^{NS} (2.21)	0.05 ^{NS} (0.90)	1.23* (0.47)

Figures in the parentheses are the standard errors; * Significant at 5% level of significance; ** Significant at 1 % level of significance; NS, not significance

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An exploratory study on farm diversification in Himachal Pradesh

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Abstract

The study was conducted in five districts viz. Una and Bilaspur representing zone I, Kangra and Mandi representing zone II and Kullu representing the Zones III and IV of Himachal Pradesh. There was a total sample of 360 respondents (72 in each district). Enterprise-wise gross income as realized by the farmers during 2012-13 formed the basis of present investigation. In all 103 sub -farming systems were identified. The maximum number of sub-farming systems was under Livestock based system (46) followed by cereals based (28), fruit based (15), vegetable based (10), other enterprises based (2) and oilseed based (1). Based on the adoption of sub-farming systems by larger number of households, the most preferred farming systems were (first two from the first four categories): Livestock + cereals (26 households), Livestock + cereals + fodder + vegetables (22 households), Cereals + livestock (28 households), Cereals + livestock + fodder + vegetables (14 households), Fruits (15 households), Fruits + livestock (14 households), Vegetables + livestock (6 households), and Vegetables + livestock + cereals (2 households). Livestock based farming systems followed by cereals based farming systems were the dominating farming systems in Zone I and II of Himachal Pradesh. In these zones 63.9 and 59.7% of the farmers were dependent on Livestock based farming systems and 33.3 and 36.8% farmers, respectively, were dependent on cereals based farming systems. In Zone III fruit growing was main activity and 72.2% of the households were dependent on fruit based farming systems. This was followed by vegetable based farming systems from which 23.6% of the households earn their livelihood. Overall fruits (36.4%) had highest share in the gross income which was followed by livestock production (28.77%), cereals (23.28%) and vegetables (8.11%).

Key words: Farming system, cereal based, livestock based, fruit based, vegetable based

Agricultural scenario in Himachal Pradesh is quite different from those of other parts of the country. It is a mountainous state with a wide agroclimatic variation in terms of rainfall, elevation and soil type. Based on agro-climatic variations, the state has been divided into four agroclimatic zones. Based on study during 2005-06, nearly 87.03% of the farmers are marginal (<1.0 ha) and small (1-2 ha) having landholding 26.67 and 25.27% (51.94%), respectively, of the total (Statistical Outlines of Himachal Pradesh, 2013). Semi-medium (9.48%) having land holding 2-4 ha and medium farmers (3.12%) having land holding 4-10 ha are possessing 24.82 and 17.04%, respectively of the total land holding. The large farmers (>10.0 ha) which are just 0.38% (of 933383 holdings) possessing 6.2% of the total land holding (968344.7 ha). As majority of farmers are marginal and small, income from these farms cannot be raised up to the desired level to sufficiently alleviate poverty unless existing crop production systems are diversified through inclusion of high value crops (Singh 2009; Hari Om *et al*. 2008). Furthermore, increased dependence on one or two major cereal crops (wheat, rice, etc.) witnessed after the green revolution makes the farming economy vulnerable to price fluctuation arising due to demand-supply or export-import equations especially after the WTO (World Trade Organization) began influencing markets. Crop diversification on the other

hand, can better tolerate the ups and downs in the market value of farm products and may ensure economic stability for farming families. The adverse effects of aberrant weather, such as erratic and scanty rainfall and drought are very common in a vast area in agricultural production of the state. Under these aberrant weather situations, dependence on one or two major cereals (rice, wheat, etc.) is always risky. Hence, farmers have diversified their farm through substitution of one crop or mixed cropping/inter-cropping as a tool to mitigate problems associated with aberrant weather as well as to sustain their livelihood. Further livestock as is an integral component of agricultural production system is emanating as an income oriented enterprise (Hari Om et al. 2008). The present study was therefore, executed to have preliminary information about the extent of farm diversification in the state.

Materials and methods

The study was conducted in five districts viz Una and Bilaspur representing zone I, Kangra and Mandi representing zone II and Kullu representing the Zones III and IV of Himachal Pradesh. In each district two blocks were randomly selected. In each block, three villages/ panchayats were randomly selected and in each village/ panchayat 12 farmers representing marginal (having land holding <1.0 ha), small (1-2 ha), semi-medium (2-4 ha) and medium (>4 ha) were randomly selected. Thus there was a total sample of 360 respondents (72 in each district). Enterprise/Component-wise gross income as realized by the farmers during 2012-13 formed the basis of present investigation. The gross income was assessed on a participatory mode for the enterprises such as cereals, pulses, oilseeds, sugarcane, cotton, vegetables, fruits, spices, livestock (cow, buffaloes etc), poultry, piggery, fisheries and others (farm machinery, fodders) whichever are undertaken by the respondents. The enterprise-wise gross income so assessed was noted in a pre-tested proforma/schedule.

Results and Discussion

Six types of farming systems followed in the area based on a major system were: Livestock based, Cereal based, Fruit based, Vegetable based, Other enterprises (Fodder crops, flower crops, Machinery/power tiller and hiring of bullocks, honey bees) based and Oilseeds based. Data collected based on six farming systems are depicted in Table 1. In all 103 sub-farming systems were identified. The maximum number of sub-farming systems was under livestock based system (46) followed by cereals based (28), fruit based (15), vegetable based (10), other enterprises based (2) and oilseed based (1). Based on the adoption of sub-farming systems by larger number of households, the most preferred farming systems (first two from the first three categories) were Livestock + cereals (26 households), Livestock + cereals + fodder + vegetables (22 households), Cereals + livestock (28 households), Cereals + livestock + fodder + vegetables (14 households), Fruits (15 households) and Fruits + livestock (14 households). Since Himachal Pradesh is a hilly region, the maximum sub-farming systems were either livestock based or involved livestock in the farming system. The number of farm households following livestock system was also highest in the study area.

As a whole importance of Livestock based farming systems in terms of contribution to farm income in the area was next only to fruit based farming systems. The share of fruit based farming system was 42.19% followed by Livestock based farming systems (31.75%), cereal based (18.98%), vegetable based (5.78%), others (1.12%) and oilseed based (0.19%). Share of six most important farming systems towards total income *viz*. livestock + cereals, livestock + cereals + fodder + vegetables, cereals + livestock, cereals + livestock + fodder + vegetables, fruits, fruits + livestock, vegetable + livestock and vegetable + livestock + lereals was 3.04, 3.79, 2.93, 3.49,10.24 and 9.32, respectively. This clearly depicting that 'fruits' and 'fruits + livestock' were most important in terms of income as these two farming systems were contributing 19.56% share in total farm income in the area. Therefore, the hypothesis that the major farming system in the study area was livestock based farming system was rejected.

There were clear cut indications that fruits are more paying, followed by vegetables, livestock and the cereals and other field crops the least. Jha et al (2009) have also reported similar findings. Therefore, this is the time, policy interventions have to be geared to cereals and other field crops so that these may get major portion of government investment or farmers should be encouraged to introduce more paying enterprises.

Income base of Major Farming Systems

Farming systems were identified based on the relative share in farm income from different farm enterprises (Table 2).

Livestock based farming systems followed by cereals based farming systems were the dominating farming systems in Zone I and II of Himachal Pradesh. In these zones 63.9 and 59.7% of the farmers were dependent on

Table 1. Major Farming Systems along with important sub farming systems (adopted by at least by 5 households) of sample household in HP

Farming Systems	No of sub farming sys-tems	No of Households					% share of total income
		Ma	S	SM	M	All	
Livestock based	**46**	**109**	**52**	**13**	**6**	**180**	**31.75**
Livestock +Cereals+Vegetables+Other		4	6	0	2	12	3.26
Livestock +Cereals+Other		9	0	0	0	9	1.73
Livestock +Cereals		24	2	0	0	26	3.04
Livestock		14	2	2	1	19	1.98
Livestock +Cereals+Vegetables		6	0	0	0	6	4.56
Livestock+Cereals+Other Specify+Vegetables		10	11	1	0	22	3.79
Livestock+Vegetables		2	2	1	0	5	0.80
Livestock+Cereals+Spices+Oilseeds+Pulses+Vegetables		2	3	2	0	7	1.18
Livestock+Cereals+Pulses+Oilseeds+Vegetables+spices		5	0	0	0	5	0.58
Livestock+Other		1	4	1	0	6	0.91
Cereal based	**29**	**27**	**52**	**12**	**11**	**102**	**18.98**
Cereals+Livestock+Vegetables+Other		2	2	1	0	5	1.17
Cereals + Livestock + Other		2	4	1	0	7	0.94
Cereals		4	1	0	0	5	0.29
Cereals+Livestock		11	13	2	2	28	2.93
Cereals+Livestock+Other +Vegetables		1	9	1	3	14	3.49
Cereals+Livestock+Oilseeds+Pulses+Vegetables+Spices		4	2	3	0	9	1.82
Fruit based	**15**	**28**	**18**	**7**	**2**	**55**	**42.19**
Fruits		6	7	2	0	15	10.24
Fruits +Livestock		10	3	1	0	14	9.32
Fruits+Vegetables+Livestock+Cereals		1	3	1	0	5	4.92
Vegetables based	10	13	6	0	0	19	5.78
Vegetables+Livestock		6	0	0	0	6	1.24
Vegetables+Fruits+Cereals		1	1	0	0	2	1.18
Oilseeds based	**1**	**0**	**1**	**0**	**0**	**1**	**0.19**
Other enterprises based	**2**	**0**	**2**	**0**	**1**	**3**	**1.12**
Grand Total	103	177	131	32	20	360	100.00

Ma, marginal; S, small; SM, semi-medium; M, medium

Table 2. Farm size wise number of farmers in different farming systems in the study area

Farming Systems	Category									
	Marginal		Small		Semi Medium		Medium		All Farms	
	No.	%	No.	%	No.	%	No.	%	No.	%
Low hills (Zone I)										
Livestock based	47	88.7	33	51.6	8	57.1	4	30.8	92	63.9
Cereals based	5	9.4	29	45.3	6	42.9	8	61.5	48	33.3
Fruit based	0	0.0	0	0.0	0	0.0	1	7.7	1	0.7
Vegetable based	1	1.9	1	1.6	0	0.0	0	0.0	2	1.4
Oilseeds based	0	0.0	1	1.6	0	0.0	0	0.0	1	0.7
Total	53	100.0	64	100.0	14	100.0	13	100.0	144	100.0
Mid hills (Zone II)										
Livestock based	60	73.2	19	42.2	5	45.5	2	33.3	86	59.7
Cereals based	21	25.6	23	51.1	6	54.5	3	50.0	53	36.8
Fruit based	1	1.2	1	2.2	0	0.0	1	16.7	3	2.1
Vegetable based	0	0.0	2	4.4	0	0.0	0	0.0	2	1.4
Oilseeds based	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Others	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Total	82	100.0	45	100.0	11	100.0	6	100.0	144	100.0
High hills (Zone III)										
Livestock based	2	5.0		0.0		0.0		0.0	2	2.8
Cereals based	1	2.5		0.0		0.0		0.0	1	1.4
Fruit based	27	67.5	17	77.3	7	100.0	1	100.0	52	72.2
Vegetable based	12	30.0	5	22.7		0.0		0.0	17	23.6
Oilseeds based		0.0		0.0		0.0		0.0		0.0
Total	42	100.0	22	100.0	7	100.0	1	100.0	72	100.0
Himachal Pradesh										
Livestock based	109	65.0	52	36.4	13	37.4	6	22.9	180	50.0
Cereals based	27	15.5	52	39.4	12	42.6	11	44.3	102	28.3
Fruit based	28	13.9	18	16.3	7	20.0	3	32.9	56	15.6
Vegetable based	13	6.6	8	7.2	0	0.0	0	0.0	21	5.8
Oilseeds based	0	0.0	1	0.8	0	0.0	0	0.0	1	0.3
	175	100.0	131	100.0	32	100.0	20	100.0	360	100.0

Livestock based farming systems and 33.3 and 36.8% farmers, respectively, were dependent on cereals based farming systems. In Zone III fruit growing was main activity and 72.2% of the households were dependent on fruit based farming systems. This was followed by vegetable based farming systems from which 23.6% of the households earn their livelihood. On an average, livestock based farming system was the major activity for more than 65% marginal farmers, 36% small farmers, 37% semi-medium farmers and 23% medium farmers. Cereals based farming systems was the main activity of the small (39.4%), semi-medium (42.6%) and medium farmers (44.3%). However, irrespective of the farm size, overall the livestock based farming system (50%) was the main activity followed by cereals based (28.3%), fruit based (15.6%) and vegetable based (5.8%) in that order.

A perusal of Table 3 revealed that most of the farmers of Himachal were following livestock based farming system and were earning 60% of the gross income from the system. The marginal, small, semi medium and medium farmers, respectively, were earning 68.9, 56.3, 51.3 and 39.3% of the total income from livestock based farming system. Cereals based farming system was also followed by all categories of farmers and it contributed 62.0, 58.3, 63.3 and 62.6% of total income of marginal, small, semi medium and medium farmers, respectively.

Marginal, small, semi medium and medium farmers following fruit based farming systems earned gross income of about 90, 87, 85 and 67% from fruit crops, respectively. Marginal and small farmers following vegetable based farming system were earning about their 60% of the gross income from the system.

The overall analysis clearly indicated that fruits (36.4%) had highest share in the gross income which was followed by livestock production (28.77%), cereals (23.28%) and vegetables (8.11%). Jha et al (2009) have also reported similar findings where potential of fruits and vegetables as the new source of growth was examined in terms of supply and demand side factors. There have also been studies (Joshi et al. 2007) eulogizing the role of fruits, vegetables and similar exportable crops often termed as 'high value' crops in the ongoing diversification-led growth of agriculture. Pulses (0.30%), oilseeds (0.46%), sugarcane (0.03%), spices (0.27%) and poultry (0.05%) had negligible share in gross total income. Piggery and fishery were not existed in the study area.

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Table 3. Farm size wise share in gross income of different Farming Systems in Himachal Pradesh

Particular	Farm category				
	Marginal	Small	Semimedium	Medium	All
			Livestock based		
Farm size	0.51	1.40	3.09	4.33	1.08
Cereals	23.23	35.24	38.71	49.90	31.27
Pulses	0.12	0.43	0.55	0.26	0.29
Oilseeds	0.25	0.62	0.50	0.38	0.42
Sugarcane	0.00	0.00	0.55	0.00	0.07
Vegetable	3.01	3.55	2.28	7.29	3.41
Fruit	0.46	0.14	1.50	0.00	0.44
Spices	0.28	0.50	2.68	1.03	0.70
Livestock Production	68.93	56.28	51.28	39.30	60.19
Others	3.72	3.24	1.93	1.85	3.21
Total	100.00	100.00	100.00	100.00	100.00
			Cereals based		
Farm size	0.54	1.32	2.68	4.73	1.64
Cereals	62.01	58.30	63.26	62.58	60.78
Pulses	0.36	0.36	0.47	0.25	0.36
Oilseeds	0.76	0.70	1.83	0.54	0.88
Sugarcane	0.00	0.00	0.00	0.11	0.03
Vegetable	1.00	2.58	2.22	3.99	2.56
Fruit	0.00	2.34	0.00	2.00	1.58
Spices	0.29	0.12	0.23	0.13	0.17
Livestock Production	34.15	31.75	28.89	27.18	30.39
Others	1.43	3.85	3.10	3.23	3.26
Total	100.00	100.00	100.00	100.00	100.00

(continued from last page)

Particular	Farm category				
	Marginal	Small	Semimedium	Medium	All
Farm size	0.51	1.40	3.09	4.33	1.08
			Fruit based		
Farm size	0.50	1.58	1.84	3.40	1.57
Cereals	1.59	0.71	0.96	32.76	1.85
Pulses	0.00	0.00	0.00	0.00	0.34
Oilseeds	0.01	0.00	0.00	0.00	0.03
Vegetable	3.16	8.86	12.29	0.00	6.86
Fruit	90.11	86.57	85.46	67.24	86.14
Spices	0.00	0.01	0.00	0.00	0.01
Livestock Production	4.85	3.85	1.29	0.00	4.07
Others	0.28	0.00	0.00	0.00	0.70
Total	100.00	100.00	100.00	100.00	100.00
			Vegetable based		
Farm size	0.93	1.62	-	-	0.83
Cereals	3.57	7.06	-	-	5.30
Pulses	0.05	0.00	-	-	0.00
Vegetable	72.00	46.51	-	-	60.09
Fruit	9.86	33.58	-	-	20.97
Livestock Production	12.99	10.72	-	-	11.93
Others	0.00	2.12	-	-	1.72
Total	100.00	100.00	-	-	100.00
			Others		
Farm size	-	1.50	-	16.00	6.33
Cereals	-	34.40	-	32.15	32.99
Oilseeds	-	0.00	-	1.48	0.93
Livestock Production	-	20.53	-	11.56	14.89
Others	-	45.07	-	32.59	37.23
Total	-	100.00	-	100.00	100.00
			Oilseeds based		
Farm size	-	1.6	-	-	1.6
Oilseeds	-	71.04	-	-	71.04
Vegetable	-	1.68	-	-	1.68
Livestock Production	-	24.20	-	-	24.20
Others	-	3.08	-	-	3.08
Total	-	100.00	-	-	100.00
			All Farm		
Farm size	0.54	1.39	2.66	5.04	1.34
Cereals	14.80	24.29	28.63	54.38	23.28
Pulses	0.39	0.21	0.30	0.21	0.30
Oilseeds	0.16	0.67	0.61	0.55	0.46
Sugarcane	0.00	0.00	0.18	0.06	0.03
Vegetable	2.68	8.38	6.54	6.41	8.11
Fruit	44.03	37.80	36.97	5.12	36.40
Spices	1.00	0.18	0.93	0.36	0.27
Livestock Production	33.90	26.37	24.43	27.43	28.77
Poultry production	1.13	0.11	0.00	0.00	0.05
Others	1.81	2.43	1.40	5.47	2.51
Total	100.00	100.00	100.00	100.00	100.00

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Short Note

Response of maize - wheat cropping system to NPK in low hills of Himachal Pradesh

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Abstract

An on-farm experiment was conducted in sub-tropical low hills zone of Himachal Pradesh to study the response of major plant nutrients in maize-wheat cropping sequence. Five treatments *viz*. control, N, NP, NK and NPK at recommended rates to the component crops were evaluated at seventeen locations for the two consecutive cropping seasons of 2007-08 and 2008-09. Results of the study revealed that application of recommended dose of NPK resulted in significantly higher grain yield of maize and wheat, maize equivalent yield, gross return and net return over rest of the treatments. Recommended NPK resulted in 85% and 53% higher maize grain equivalent yield and INR 30150 and INR 24626 more net return over control and recommended N, respectively. The response in terms of kg grain per kg of nutrient applied was higher for applied phosphorus (20.85 kg maize grain euivalent) followed by potash (19.19) and nitrogen (5.69).

Key words: Maize-Wheat, Cropping Sequence, Nutrients.

In Himachal Pradesh 84% of the cropped area is rain fed. In this area, maize-wheat is the most important cropping sequence. In the sub-montane and low hills zone-1, this sequence occupies an area of 111780 ha as against 21600 ha under rice-wheat and 3740 ha by oilseed-pulses cropping systems. The productivity of the maize-wheat sequence is low which needs to be increased. The 57% of the farmers in the zone are marginal (< 1.0 ha) and 19% are small (1-2 ha) land holders. They follow traditional and subsistence farming and have low risk bearing capacity. The major constraint identified is the low use of fertilizers. In general, levels of nutrients applied are quite inadequate as is evident that in Himachal Pradesh, N, P_2O_5, K_2O use was 32.6, 9.2, 7.6 kg/ha, respectively (Anonymous 2004). Keeping in view these facts, under All India Coordinated Research Project on Cropping Systems the present study was conducted to determine the response of maize-wheat cropping system to NPK.

An on-farm investigation under All India Coordinated Research Project on Cropping Systems was carried out for 2 years (2007-2009) within NARP Zone-1 of Himachal Pradesh. In all 5 treatments (Table 2) were tested at 34 locations in Una, Hamirpur and Kangra districts during the two consecutive years. Each year the trials were conducted at 6 locations in Una at Kalruhi and Nandpur villages, 3 locations in Kangra at village Khabli (Tehsil Dehra), and 8 locations in Hamirpur at Rangas and Kohla villages.

Sowing and harvesting of the crops were done in the first to second fortnight of June and second fortnight of September for maize and first fortnight of November and second fortnight of April, respectively, for wheat each year. Recommended dose of N, P_2O_5, K_2O for maize was 90, 45, 30 and that for wheat was 80, 40, 40 kg/ha, respectively. Recommended package of practices were followed for rest of the management practices for individual crops in the cropping sequence.

The composite soil samples (0-15 cm) from each location were analyzed to determine the initial soil status in respect of soil pH (1:2.5) (Jackson,1967), available N (Subbiah and Asija,1956), P (Watanable and Olsen 1965), K (Merwin and Peech 1951) and organic C (Walkley and

Black, 1934) content.

The average annual precipitation recorded was 795 mm during 2007-08 and 1479 mm during 2008-09, respectively, whereas mean maximum and minimum temperature of the test sites varied from 28.9 to 29.1 ^{o}C and 16.2 to 16.9 ^{o}C, respectively, throughout the period of study.

Response of a component crop of the cropping sequence to the applied N was calculated by subtracting the yield under control from that under N treated plot, whereas response to applied P and K was calculated by subtracting, respectively, the yield of NK and NP treated plots from that of NPK treated plots. Same way cropping system response to a particular nutrient in terms of kg maize grain per kg nutrient applied was worked out by dividing the differences in maize equivalent yields from the respective treatments by the total amount of nutrient applied during *kharif* and *rabi.*

The soils were inceptisols having soil texture loamy sand to silty clay loam with pH 6.3 to 7.5, low to medium in respect of available nitrogen, and medium to high in respect of available phosphorus and potash content (Table 1).

A perusal of results on grain yield (Table 2) shows that application of N or its combination with P or K or both significantly increased the grain yield compared to that under control plots both in maize as well wheat during both the years of experimentation. The higher yields following the recommended application of NPK to the individual crops tended to increase the maize equivalent yield significantly over rest of the treatments. The recommended fertility level increased maize equivalent yield by about 88 and 83% over control and by about 53 and 54% over N only during 2007-08 and 2008-09, respectively. The increase in yield might be due to favorable influence on soil fertility and micro climatic conditions. These findings are in conformity with those obtained by Chaudhary *et al*. (2000 a&b); Sharma *et al*. (2007).

Table 1. Soil fertility status before the sowing of *kharif* crops

Village	pH	OC (%)	Available Nutrients (kg/ha)		
			N	P	K
Nandpur	7.5	0.57	238.9	26.1	145.6
Kalruhi	7.3	0.43	128.0	17.7	138.1
Khabli	6.7	0.91	243.2	53.0	283.7
Rangas	6.7	0.59	156.8	16.0	218.4
Kohla	6.3	0.63	188.8	23.0	262.6

Table 2. Treatment effects on yield (kg ha^{-1}) of maize-wheat cropping system

Treatment	2007-08			2008-09		
	Maize grain	Wheat grain	Maize equivalent	Maize grain	Wheat grain	Maize equivalent
Control	1841	1800	4611	1972	1828	4784
Recommended N for the component crop	2211	2233	5646	2281	2212	5685
Recommended NP for the component crop	2996	2871	7413	3030	2827	73769
Recommended NK for the component crop	2836	2620	6867	2892	2632	6941
Recommended NPK for the component crop	3550	3329	8672	3731	3273	8766
LSD (P=0.05)	168	117	675	137	128	497

Recommended dose (kg/ha), Maize-90:45:30 and Wheat-80:40:40

The highest maize and wheat yield following recommended dose of nutrients (NPK) fetched highest mean gross (INR76884) and net return (INR 47602) over rest of the treatments. On an average, the recommended NPK increased the gross and net return by INR 35674 and INR 30150 per ha over control and INR 27165 and INR 24626 per ha over N alone, respectively (Table 3). Similarly highest B:C was obtained from the plots applied recommended NPK. In fact, net returns and B: C followed the trend as was observed for maize equivalent yield. When NP and NK were compared, it was found that application of NP proved better than NK which revealed greater response to phosphorus application.

In general highest response was obtained to applied phosphorus followed by applied potash and nitrogen in both the crops during both the years of study. Similarly cropping system response (kg maize grain/kg nutrient applied) of maize-wheat crop sequence was also highest to applied P followed by K and N (Table 4). On an average, the response of maize–wheat cropping system in terms of maize grain equivalent yield/kg nutrient was: 5.69 kg grain/kg N applied, 20.85 kg grain/kg P applied and 19.19 kg grain/kg K applied. This was in line with our earlier findings (Sharma *et al*. 2007). The lowest response to applied N may be due to the fact that it is subjected to more losses as compared to P and K.

Table 3. Treatment effects on economics of maize-wheat cropping system

Treatment	Returns (INR/ha)						B:C Ratio		
	Gross			Net					
	2007-08	2008-09	Mean	2007-08	2008-09	Mean	2007-08	2008-09	Mean
Control	40259	42162	41210	16501	18404	17452	0.69	0.77	0.73
Recommended N for the component crop	49307	50131	49719	22564	23388	22976	0.84	0.87	0.85
Recommended NP for the component crop	64236	65298	63267	35474	36536	36005	1.23	1.27	1.25
Recommended NK for the component crop	60125	61488	60806	33042	34405	33723	1.22	1.27	1.25
Recommended NPK for the component crop	75987	77781	76884	46705	48499	47602	1.59	1.66	1.63
LSD(P=0.05)	2370	2598	-	2370	2598	-	0.08	0.09	-

Table 4. Response of maize-wheat cropping system to applied nutrients

Crop	Response (kg grain/kg nutrient applied)								
	N			P_2O_5			K_2O		
	2007-08	2008-09	Mean	2007-08	2008-09	Mean	2007-08	2008-09	Mean
Maize	4.11	3.43	3.77	16.66	17.64	17.15	19.64	21.87	20.75
Wheat	5.41	4.80	5.11	16.83	15.69	16.26	10.56	15.69	13.12
Maize Equivalent	6.09	5.29	5.69	21.00	20.69	20.85	17.70	20.69	19.19.

The findings of the present investigation envisaged the positive impact of combined application of all the three basic (NPK) nutrients at recommended rates to the component crops in increasing their yield and thus the total productivity of rain fed maize-wheat cropping sequence in sub-montane and low hills sub-tropical zone of the State.

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Short Note

Effect of genotypes under different dates of sowing on yield of linseed (*Linum usitatissimum* L. Griesb.) in Himachal Pradesh

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Abstract

Sowing of suitable variety at optimum time is of primary importance among various factors responsible for higher yield of linseed. To ascertain the optimum date of sowing for linseed genotypes, an experiment comprising of three dates of sowing (*i.e.* October last week, November 2nd week and November 3rd week) and four genotypes (*viz.* 'RLC-100', 'KL-221', 'LC-54'and 'Janaki') was conducted at Palampur during *rabi* 2006-07. The crop sown on October last week gave significantly higher yield over November sown crop because of higher plant stand, growth and more capsules per plant. 'KL-221'and 'LC-54' being at par with zonal check (Janaki) resulted in significantly taller plants and higher primary branches and seed yield. 'KL-221' yielded significantly higher over other tested genotypes when it was sown during October last week.

Key words: Linseed, genotypes, dates of sowing, yield

Linseed (*Linum usitatissimum* L. Griesb.) is an important oilseed *rabi* crop next to rapeseed and mustard in Himachal Pradesh. Among various factors responsible for its low yield, sowing time and varietal selection are of primary importance. Sowing time is a non-monetary input, but has noticeable impact on productivity of crop. Planting dates significantly affect growth characters, yield and its component as well as oil yield in flax (Al-Doori, 2012). Sowing dates have been shown to provide differential growth conditions such as temperature, precipitation and growth periods. The appropriate sowing date is very important since it ensures good seed germination, as well as timely appearance of seedling and optimum development of the root system. Genotypes differ from each others in genetic make up for growth and yield. Fontana *et al.* (1996) tested ten linseed cultivars and observed their variation for seed yield, 1000-seed weight and oil yield. Optimum planting time range of different cultivars varies with regions depending on growing conditions of a specific tract that could be assessed by planting at different times. Therefore, to ascertain the optimum dates of sowing for linseed genotypes the present study was undertaken.

The present study was carried out during *rabi* 2006-07 at Experimental Farm of Oilseed Section, CSK HPKV, Palampur. The experiment was conducted in Factorial Randomized Block Design keeping 12 treatment combinations, comprising of three dates of sowing (October last week, November 2nd week and November 3rd week) and four genotypes ('RLC-100', 'KL-221', 'LC-54'and 'Janaki') in three replications. The crop was raised with recommended package of practices. The soil of the experiment site was silty clay loam in texture with pH 6.1 and medium available nitrogen, phosphorus and potassium. Fertilizer nutrients viz. N, P_2O_5 and K_2O were applied at 50, 40 and 20 kg/ha, respectively. The crop was sown at 23 cm apart rows using seed rate of 40 kg/ha. For recording plant population, the total number of plants present in 1m row length were counted from two randomly selected places in each net plot, averaged and expressed in thousand plants/ha. Plant height, primary and secondary branches and capsules/plant were recorded from the selected five plants in each net plot. After maturity, the crop was harvested from the net plot area, sun dried and threshed with wooden mallet and the seed yield was expressed in kg/ha.

Table 1. Effect of linseed genotypes and seed rate on growth, yield attributes and seed yield

Treatment	Plant stand ('000/ha)	Plant height (cm)	Primary branches	Secondary branches	Capsules/ plant	Seed yield (kg/ha)
Date of sowing						
October, Last week	1022	57.8	5.0	1.96	29.6	1010
November, 2nd week	929	55.0	4.6	1.85	28.0	836
November, 3rd week	855	50.6	5.2	2.09	28.2	621
SE (m±)	16.1	0.28	0.04	0.04	0.38	22.1
LSD (P=0.05)	47.1	0.80	0.11	0.11	1.13	65
Variety						
RLC-100	818	43.6	4.9	1.45	26.5	701
KL-221	877	52.8	5.4	2.5	32.5	870
LC-54	934	60.6	4.2	1.70	25.3	832
Janaki	1112	60.8	5.4	2.22	30.1	885
SE (m±)	18.6	0.32	0.04	0.06	0.67	25.5
LSD (P=0.05)	54.4	0.93	0.12	0.19	1.96	75

Linseed crop sown during October last week had maximum plant stand with tallest plants (Table 1). This was followed by November 2nd week sown crop. Mean temperature of about 20°C and rainfall of 96.8 mm during October favoured germination and better establishment of crop, while, the values for these climatic parameters were below optimum *i.e.* 15°C and 22.4 mm, respectively, in November. October last week sown crop was significantly superior for capsules/plant over November sown crops. However, crop sown on November 3rd week had highest primary and secondary branches followed by October last week sown crop. Because of higher plant stand with good growth and more capsules per plant, October last week sown crop was higher yielding over November sown crops (*i.e* November, 2nd or November, 3rd week). November 2nd week sown crop was superior to November 3rd week sown linseed for its seed yield. The increase in the seed yield due to October sown crop over November 2nd and November 3rd week sown crop was 20.8 and 62.6%, respectively. Significant reduction in seed yield and harvest index were also observed with successive delay in sowing from October to November by other workers (Shaikh *et al.*, 2009). Similarly, Chauhan *et al.* (2008) also reported that late sowing considerably reduced seed as well as stover yield of linseed. Except primary branches per plant and plant height, all other growth and yield attributes like capsules per plant, seeds per capsules, seed yield per plant and 1,000-seed weight were more under 30th October sowing than that under November sowing (Mahapatra *et al*., 2009).

As far as genotypes are concerned, significantly highest plant stand was recorded for zonal check 'Janaki' followed by test genotypes 'LC-54'and 'KL-221'. Zonal check 'Janaki' had significantly tallest plants with more number of primary branches. However, 'LC-54'and 'KL-221'were at par with it for plant height and primary branches, respectively. 'KL-221'resulted in significantly higher secondary branches and capsules/plant, which was followed by 'Janaki'. 'KL-221'and 'LC-54'being at par with Janaki had significantly higher seed yield (Table 1). This was due to better plant stand with more yield attributes over 'RLC-100'. Pandey *et al.* (2002) also found that the biomass and net primary productivity were comparatively higher in linseed cv. 'LC-54'than cv. NP-5. Therefore 'LC-54' has been recommended for Punjab, H.P., Rajasthan and Haryana (Singh *et al.*, 2009). 'RLC-100' had lowest plant stand with shortest plant height having fewer primary and secondary branches. The increase in the seed yield by 'Janaki', 'KL-221'and 'LC-54'over 'RLC-100' was 26.2, 24.1 and 18.7%, respectively.

Interaction effect of sowing time and genotypes was significant on plant stand and seed yield (Table 2). 'Janaki' sown on either October last week or November, 2nd week had higher plant stand over rest of the combinations. 'LC-54'sown on October last week being at par with 'Janaki' sown on November, 3rd week were the other better combination in this regard. However, 'KL-221' was also at par to

Table 2. Interaction effect of date of sowing and variety on plant population and seed yield of linseed

Date of sowing	Variety			
	RLC-100	KL-221	LC-54	Janaki
	Plant stand (000'ha)			
October, Last week	908	964	1043	1175
November 2nd week	814	857	914	1135
November 3rd week	735	810	847	1029
SE (m±)	32.2			
LSD (P=0.05)	94			
	Seed yield (kg/ha)			
October, Last week	843	1252	1040	903
November, 2nd week	624	838	825	1057
November, 3rd week	637	520	632	697
SE (m±)	44.2			
LSD (P=0.05)	130			

'Janaki' sown on November, 3rd week. 'KL-221'yielded significantly higher over 'Janaki' and other genotypes (*i.e.* 'LC-54'and 'RLC-100') sown during October last week. The 'LC-54' sown on October last week observed statistically similar to 'Janaki' sown during November, 2nd week for seed yield of linseed (Table 2).

Therefore, it can be concluded that sowing of 'KL-221' during last week of October was the best option for getting highest seed yield of linseed under mid hill condition of Himachal Pradesh.

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Short Note

Effect of leaf crinkle disease on yield and quality of urdbean (*Vigna mungo* L. Hepper) in Himachal Pradesh

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Abstract

The study was conducted to assess the losses caused by leaf crinkle disease in terms of quantity and quality in urdbean in Himachal Pradesh. The disease is caused by *urdbean leaf crinkle virus* (ULCV) which consists of filamentous virus particles. There was significant reduction in yield components (cv. T-9) *viz*., plant height (23.8%), inter-nodal length (20.0%), pods/plant (70.0%), pod length (18.8%), seeds/pods (37.5%) and seed weight/plant (25.0%) as compared to healthy plants. Seed quality parameters viz., germination (45%), seed viability (86%), seed vigour (0.74%) and protein content (21%) were severely affected by virus infection. The severe reduction in various yield and quality parameters in the infected seed crop clearly envisages the need to control the virus by adopting effective control measures.

Key words: Leaf crinkle, urdbean, seed viability, seed vigour

Pulses constitute an important part of dietary proteins of the vegetarians. The importance of pulses as an excellent source of protein, vitamins and minerals is well established. Urdbean or blackgram (*Vigna mungo* L. Hepper) is one of the important pulses of *Phaseolus* group which holds an important position after chickpea in India. It is cultivated on an area of about 3.25 million ha with an annual production of 1.5 million tonnes (http:// www.aicrpmullarp.res.in/crop_profile. html). Leaf crinkle disease was first reported from Delhi (Nariani, 1960).

Urdbean is vulnerable to the attack of a large number of diseases. Among them leaf crinkle disease caused by *urdbean leaf crinkle virus* (ULCV) is important (Biswas *et al*. 2009). Under field conditions ULCV is more serious in blackgram than green gram and other pulses (Bashir and Zubair, 1985; Biswas *et al*. 2009). This may results in 100% yield loss during the epidemic years (Kanimozhi *et al*. 2009).

On an average, the virus has been reported to decrease grain yield by 35-81% (Bashir *et al*. 1991). Kadian (1982) reported that losses from leaf crinkle disease ranged between 2.12-93.98% in *Vigna radiata* cv. *versa* and 2.82-95.17% in *Vigna mungo* cv. T-9. The direct relation existed between the stage of plant growth at which infection occurred and yield loss. The reduction in tryptophan, increase in IAA and higher sugar content have been reported in urdbean leaves infected by leaf crinkle virus (Brar and Rataul 1990). The disease is characterized by crinkling, curling, puckering, rugosity of leaves, enlargement of leaf lamina, stunting of plants and malformation of floral organs (Kanimozhi *et al.* 2009). Infected plants produce sterile flowers and few pods (Bashir *et al.* 1991). Seed borne nature of the virus is well established and the disease has attained serious proportions (Sharma *et al*. 2014).

In Himachal Pradesh, occurrence of leaf crinkle disease has been widely encountered (Sharma *et al.* 2004) and the association of filamentous virus with leaf crinkle disease has been established (Sharma *et al*. 2014). The present study was conducted to study the effect of leaf crinkle disease on seed quality and yield components in urdbean.

The field trial was conducted at the experimental farm of the Department of Plant Pathology, CSK HPKV, Palampur, using seeds of highly susceptible cultivar T-9

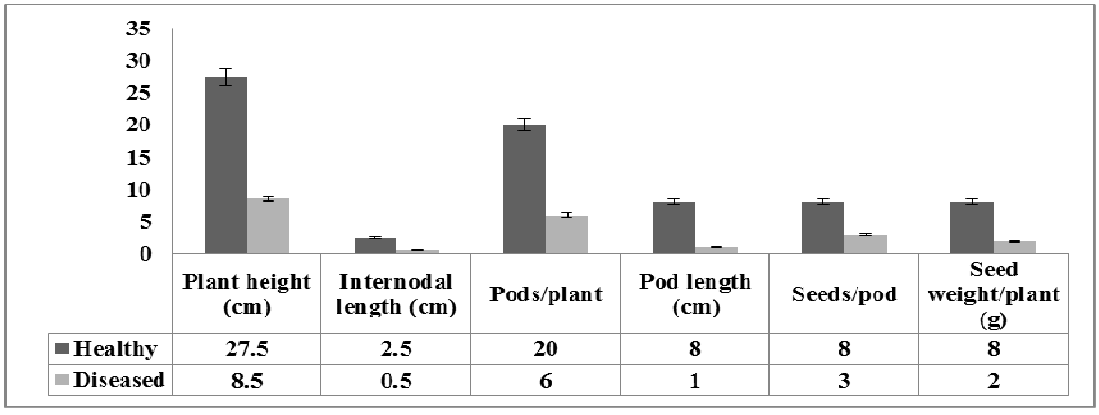
obtained from naturally infected and healthy plants. The seeds were sown in plots of 2.0m x 2.5m size with a spacing of 50cm x 20cm. The crop was raised as per standard agronomic practices. Twenty-five healthy and diseased plants were selected at random and data were recorded on various yield contributing factors *viz*., plant height (cm), internodal length (cm), number of pods/ plant, pod length (cm), seeds/pod and seed weight/plant (g).

To assess the germination percentage of healthy and virus infected seeds, a germination test was conducted by rolled towel method (Agarwal and Dadlani, 1992). Five hundred seeds placed on double layer of germination paper lined with wax paper were rolled carefully and allowed to germinate at 25± 1ºC for 7-10 days and germination percentage was recorded. The viability of healthy and diseased seeds was studied by Tetrazolium test (Moore 1973). The vigour test was conducted by following the methods of Killock and Law (1988). The protein content of healthy and virus infected seeds was determined by Kjeldajl method (Hesse 1971).

The results on yield loss assessment in urdbean due to leaf crinkle disease indicated that virus affected all the parameters of urdbean plant (Fig. 1). Plant height reduced by 23.8% compared to that of healthy plant. Similarly, infected plant (6 pods) suffered with 70% reduction in number of pods/plant. Pod length and no. of seeds per pod reduced to 18.8% and 37.5%, respectively. Inter-nodal length was decreased by 20.0% over healthy plant. The seed weight per plant was reduced by 25.0%. The reduction in yield components of urdbean by virus may lead to reduction in production and productivity of the crop. Kadian (1982) also observed significant yield reduction in the T-9 variety due to the effect of virus infection. Similar, results have been reported by Bashir *et al.* (1991).

The virus infection had pronounced effect on various seed quality parameters (Table 1). Seed germination in diseased seeds was 45% as compared to the healthy seeds (97%). Tetrazolium chloride staining test revealed that the seed viability of diseased seed was 86% as against 95% in healthy seed crop. Seed vigour was also reduced in infected seed (0.74). The virus infection also decreased the protein content of the diseased seed (21%) over the healthy seed (32.4%). Kanimozhi *et al.* (2009) also reported significant reduction in seed germination and seedling vigour in ULCV infected seed compared to healthy seed.

Due to the seed borne nature of the virus, use of healthy seeds is recommended. The virus also can effectively be controlled by rouging out of infected plants, eradication of weeds and controlling vector population. However, still there is need to further develop an effective method for the control of virus on a practical point of view.



	Plant height (cm)	Internodal length (cm)	Pods/plant	Pod length (cm)	Seeds/pod	Seed weight/plant (g)
Healthy	27.5	2.5	20	8	8	8
Diseased	8.5	0.5	6	1	3	2

Fig 1. Effect of ULCV infection on yield attributes of urdbean

Table 1. Effect of ULCV infection on seed quality of urdbean

Seed	Seed germination (%)	Seed viability (%)	Seed vigour (OD)	Seed protein (%)
Healthy	97	95	1.50	32.4
Diseased	45	86	0.74	21.0

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Short Note

Factors affecting fertility, hatchability and chick survivability in poultry germplasm under sub temperate conditions

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Abstract

An investigation was carried out to study the effect of season, genotype, age of breeder hen and source of egg collection on fertility, hatchability and chick survivability at Palampur during July 2010 to August 2012. There was significant effect of season on the fertility (P<0.01). The highest average fertility was observed in winter (90.54±0.64%) followed by monsoon (86.74±1.45%) and summer (84.73±1.67%). The highest mean fertility was found in Native, followed by Native x Dahlem Red (DR) and Native x Rhode Island Red (RIR). The highest average fertility and hatchability were observed in 40-60 week age group followed by 26-40 week and 60 and above. The source of collection of egg also has significant effect on hatchability as well as fertility (p <0.01). Eggs collected from farmer's flock had lower fertility (81.06±1.33%) and hatchability (67.61±1.80%) when compared with fertility (88.27±0.88%) and hatchability (74.70±1.17%) of farm's eggs. The hatchability operation under sub temperate condition of the region can be effectively carried out throughout the year without much reduction in fertility and hatchability, although greater care and managemental precision must be exercised in winter season both during hatching as well as brooding in the region.

Key words: Fertility, hatchability, Chick survivability

Fertility and hatchability are the most important determinants for producing more chicks from given number of breeding stock within a stipulated period. Fertility and hatchability performance of eggs depend on the number of factors like genetic, physiological, social and environmental (Jull, 1970). There are several reports indicating that genotype, age of breeder hen and season has significant effect on hatchability traits. Therefore, the present investigation was planned to study the effect of season, genotype, age of breeder hen and source of egg collection on fertility, hatchability and chick survivability in sub temperate conditions of Palampur in Himachal Pradesh.

The study was conducted at University Poultry Farm, CSKHPV Palampur during July 2010-August 2012. Hatching eggs were collected from breeder hens reared in the farm and purchased from farmer's flock. Breeder hens maintained in the farm belongs to three different genotype *viz*. Native, crosses of native with Dahlem Red (DR) and crosses of native with Rhode Island Red (RIR). These breeder hens were categorized in to three different age group viz. 26-40, 41-60 and more than 60. Three different seasons *viz* summer (April to June), monsoon (July to October) and winter (November – March) were considered throughout the year. Breeder hens at farm were reared under deep litter system with standard feeding and management practices.

One breeder cock was provided for every 10 hens. One nest box was provided for every three hens. Hatching eggs were collected thrice daily and sorted according to genotype of hens. Eggs with sound shell, proper shape were selected while cracked abnormal and odd colored eggs were excluded. Eggs were properly cleaned and stored around 15ºC with 75% relative humidity for 3-5 days. While collecting the local eggs from farmer's flock managed under traditional backyard production system proper care was taken to collect the freshly laid sound and well shaped eggs. The collection was done from farmers maintaining the adequate hen: cock ratio so as to ensure the adequate fertility. These eggs were stored under the

same condition as farm eggs, but maximum up to 3 days. Eggs were hatched by electric incubator having the capacity of 15000 eggs for setter and 5000 eggs for hatcher. Before introducing new batch of hatching eggs, the incubator was cleaned and fumigated to prevent pathogenic infection. Setting and hatching temperature for dry bulb was 99ºF and 98ºF, respectively and for wet bulb was 85ºF and 90ºF, respectively so as to give desired relative humidity throughout the entire incubation period. The temperatures were monitored thrice daily and adjustment was made if needed. The eggs were identified properly for different classification groups and were turned after one hour automatically by programmed device. On the 7^{th} and 12^{th} days of incubation, the eggs were candled to identify and remove infertile eggs. The remaining eggs were transferred from setting trays to hatching trays on 19^{th} day of incubation. On 21^{st} day, hatched out chicks were collected and counted. Hatchability percentage was calculated by the number of chicks hatched divided by total number of eggs set and multiplied by 100. Data were subjected to analysis of variance (ANOVA) with the help of a computer package program (SAS). Least Significant Difference (LSD) test was performed to compare differences among the means.

There was significant effect of season on the fertility ($P<0.01$) (Table 1.). Among different season of hatching the highest average fertility was observed in winter (90.54±0.64%) followed by monsoon (86.74±1.45%) and summer (84.73±1.67%). Significant effect of season on fertility was also reported by Islam *et al*. (2008) and Chowdhury *et al*. (2004). The average hatchability in summer, monsoon and winter was 72.42±1.98%, 73.34±2.08% and 75.40±1.34%, respectively. The difference between the hatchability among different seasons was

Table 1. Least Square Means ± SE of fertility, hatchability and chick survivability in sub temperate Palampur region of HP

Sub-class description	Batches (No)	Eggs/batches (No)	Fertility (%)	Hatchability TES (%)	Chick Survivability (%)
Overall mean	54	195.00±13.66	87.19±0.84	73.65±1.08	94.62±0.25
Season					
Summer	18	215.22±17.88	$84.73±1.67^{A}$	72.42±1.98	$95.56±0.33^{A}$
Monsoon	20	174.25±20.67	$86.74±1.45^{AB}$	74.20±2.08	$94.86±0.34^{A}$
Winter	16	198.19±31.76	$90.54±0.64^{B}$	74.35±1.34	$93.27±0.49^{B}$
		NS	**	NS	**
Genotype					
Native	15	184.46±27.52	86.33±1.50	75.79±2.07	94.72±0.43
Native x DR	15	245.86±25.62	88.34±1.02	75.36±1.31	94.55±0.65
Native x RIR	24	168.58±20.25	87.02±1.55	71.24±1.82	94.60±0.32
		NS	NS	NS	NS
Age (weeks)					
26-40	14	225.76±33.66	$85.54±1.46^{A}$	$73.41±2.20^{AB}$	95.26±0.44
40-60	20	190.55±23.02	$91.19±0.47^{B}$	$78.68±1.11^{A}$	94.87±0.39
61 and above	20	178.45±18.59	$86.26±1.56^{A}$	$70.81±1.46^{B}$	93.92±0.33
		NS	**	**	NS
Source of eggs					
Farm	46	196.54±15.73	$88.27±0.88^{A}$	$74.70±1.17^{A}$	94.62±0.26
Farmer's flock	8	186.13±19.46	$81.06±1.33^{B}$	$67.61±1.80^{B}$	94.61±0.87
		NS	**	**	NS

NS: Not significant ** Significant ($p<0.01$); DR, Dahlem Red ; RIR, Rhode Island Red

however not found statistically significant ($p>0.05$), which was in accordance with earlier report of Babiker and Musharaf (2008).

There was comparatively much greater reduction in hatchability when compared as % reduction over fertility in winter (17.9%) as compared to summer (14.5%) and monsoon (14.4%). This may be attributed to the fact that during extreme winter there was much more difficulty to continuously maintain the hatcher and setter temperature with the precision capable in other season. There were significant differences in chick survivability during different season ($p<0.01$), which was 95.56±0.33%, 94.86±0.34% and 93.27±0.49% for summer, monsoon and winter, respectively. Chicks hatched in winter season had more mortality (up to 6 week of age) followed by monsoon and summer. The comparatively higher mortality in chicks hatched during winter season can be attributed to the fact that there was difficulty in maintaining the appropriate brooding condition continuously due to low temperature especially during night hour.

Effect of genotype on fertility and hatchability has been shown in Table 1. The highest mean fertility was found in native, followed by Native x DR and Native x RIR. Similar trend was observed for hatchability but the differences for fertility and hatchability were not statistically significant ($p>0.05$).

Among three different age group of breeder hen there were statistically significant differences in the fertility and hatchability ($p<0.01$). The highest average fertility and hatchability were observed in 40-60 week age group followed by 26-40 week and 60 and above. The result of present finding was in accordance with earlier reports (Islam *et al*. 2008, Suarez *et al.* 1997 and Das 1994).

The source of collection of egg had significant effect on hatchability as well as fertility ($p <0.01$). Eggs collected from farmer's flock had lower fertility (81.06±1.33%) and hatchability (67.61±1.80%) when compared with fertility (88.27±0.88%) and hatchability (74.70±1.17%) of farm's eggs. This might be due to the fact that not all critical factors for ensuring proper collection and handling of eggs for hatching purpose were taken care at farmer's doorstep compared to standard procedure at farm. The differences in chick survivability with respect to source of collection were not significant ($p>0.05$).

The hatchability operation under sub temperate condition of the region can be effectively carried out throughout the year without much reduction in fertility and hatchability. Greater care must be exercised in winter, since the finding suggest that in spite of higher average fertility observed in winter season there was comparatively higher percent reduction in hatchability and lower chick survivability.

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Short Note

Efficacy of Nativo 75 WG against blister blight in tea [*Camellia sinensis* (L.) O. Kuntze]

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Abstract

Seven fungicidal treatments *viz*. Nativo (trifloxystrobin 25% + tebuconazole 50%) 75 WG at 75, 100 and 125 g/ha, Contaf (hexaconazole) 5 EC + Calixin (tridemorph) 80 EC at 100 + 90 ml/ha, trifloxystrobin 50 WG at 625 g/ha, Folicur (tebuconazole) 250 EW at 250 ml/ha and untreated control were evaluated during 2010 and 2011 at Palampur against blister blight in tea (*Exobasidium vexans*). The two years pooled data showed that the test fungicide Nativo 75 WG at 125 g/ha was effective against blister blight to yield 60.0% control. This was statistically significant to its constituents Folicur 250 EW and trifloxystrobin 50 WG at recommended doses. Folicur 250 EW at 250 ml/ha yielded 50.3% disease control whereas, trifloxystrobin 50 WG at 625 g/ha resulted in 37.0% disease control. Folicur 250 EW at 250 ml/ha was statistically at par with Contaf 5 EC + Calixin 80 EC at 100 + 90 g/ha to yield 47.4% disease control. No chlorosis, necrosis and epinasty were observed on juvenile pluckable shoots even at higher concentrations of the test fungicide. Hence, Nativo 75 WG at 125 g/ha was recommended against blister blight of tea.

Key words: Blister blight, fungicidal, Nativo, incidence, severity, tea.

Blister blight caused by an obligate fungus *Exobasidium vexans* Massee is the major foliar disease of tea [*Camellia sinensis* (L.) O. Kuntze] which leads to enormous crop loss and quality deterioration of made tea (Baby et al. 1998). The slopy land of Kangra valley in the Dhauladhar range of Himachal Pradesh have an acidic soil formed due to high rainfall especially during the monsoon season (Mid - June to Mid -September) is highly suitable for tea cultivation. But the cool-humid climate favours the incidence of the disease. With the onset of rainy season from July to September, the disease starts appearing as whitish blister of basidiospore mass (Plate 1) on pluckable shoots of self grown tea seedlings under mother tea bushes to serve as initial foci for further disease spread. The disease, being polycyclic in nature, assumes epiphytotic conditions within few days to cause huge crop loss. The disease perpetuates in the form of viable basidiospore in the necrotic lesions (Sugha 1997) during dormant season. The disease can be effectively controlled by copper. The systemic tridemorphs and triazoles group of fungicides have been found to be effective against the disease (Baby 2002; Thakur and Thakur 2005). However, NATIVO 75 WG—a co-ordinate fungicide of trifloxystrobin (meso-systemic) and tebuconazole (systemic) may be more effective against blister blight of tea since the disease is meso-systemic. Therefore, its bioefficacy was tested against *Exobasidium vexans* in tea.

The field trial was conducted in a permanent layout during the rainy season of 2010 and 2011 at Department of Tea Husbandry and Technology, CSKHPKV, Palampur to study the bioefficacy of NATIVO 75 WG against blister blight in tea. Seven treatments *viz*. NATIVO (trifloxystrobin 25% + tebuconmazole 50%) 75 WG at 75, 100 and 125 g/ha (18.75 + 37.5, 25 + 50 and 31.25 + 62.5 g ai/ha, respectively), Contaf (hexaconazole) 5 EC + Calixin (tridemorph) 80 EC at 100 + 90 ml/ha, trifloxystrobin 50 WG at 62.5 g/ha, Folicur (tebuconazole) 250 EW at 250 ml/ha and untreated control were tested in a randomized block design with three replications.

Plate 1. Basidiospore of *Exobasidium vexans* in tea

Each plot consisted of having 25 well established tea bushes (about 20 years old) in square. Each plot was surrounded by a buffer of two border rows to avoid drift of fungicidal spray. Three sprays of NATIVO 75 WG at 15 days interval were given after plucking round, starting with the appearance of the disease (mid August) to the disease lasts (September end). Five bushes were randomly selected in each plot and per cent disease incidence and disease severity in each plucking round were worked out as follows:

$$\text{Disease incidence (\%)} = \frac{\text{Number of diseased shoots}}{\text{Total number of shoots}} \times 100.$$

$$\text{Disease severity (\%)} = \frac{\text{Size of sporulating blisters}}{\text{Area of the shoot}} \times 100$$

In the present investigation shoot means two leaves along with a bud. Twenty randomly selected disease shoots from plucked lots were assessed for disease severity. The data were pooled and the treatments were compared at 5% level of significance. The percent data were transformed to arcsine transformation. Data on phytotoxicity symptoms like chlorosis, necrosis and epinasty on juvenile pluckable shoots of tea at different concentrations of the fungicide were recorded on 1, 3, 5 and 7 days after sprays.

The fungicidal treatments brought about significant variation in the incidence of blister blight in tea (Table 1.). All the treatments were significantly superior to the untreated control in reducing blister blight incidence. Nativo 75 WG at 125 g/ha remaining at par with Folicur 250 EW at 250 ml/ha and Contaf 5EC + Calixin 80 EC at 100 + 90 ml/ha resulted in significantly lower incidence of blister blight over other treatments. Based on disease incidence Nativo 75 WG at 125 g/ha had highest disease control of 70.1%. This was followed by Contaf 5EC + Calixin 80EC.

The fungicidal treatments also resulted in significant variation in disease severity as well. All treatments were

Table 1. Efficacy of Nativo 75 WG against blister blight of tea

Treatment	Dose (g or ml/ ha)	Blister blight (*Exobasidium vexans*)							
		Disease incidence		Mean	% Disease control	Disease severity		Mean	% Disease control
		2010	2011			2010	2011		
Nativo 75 WG	75	13.2 (21.30)	15.1 (22.8)	14.1 (22.0)	47.3	10.4 (18.81)	10.4 (18.8)	10.4 (18.8)	22.9
Nativo 75 WG	100	12.5 (20.70)	14.9 (22.7)	13.7 (21.7)	48.8	9.9 (18.34)	10.7 (19.0)	10.3 (18.7)	23.7
Nativo 75 WG	125	8.0 (16.43)	8.1 (16.5)	8.0 (16.4)	70.1	4.9 (12.79)	6.0 (14.1)	5.4 (13.4)	60.0
Trifloxystrobin 50 WG	625	12.2 (20.44)	12.1 (20.3)	12.1 (20.3)	54.8	7.6 (16.0)	9.4 (17.8)	8.5 (16.9)	37.0
Folicur 250 EW	250	9.0 (17.46)	9.4 (17.8)	9.2 (17.6)	65.6	5.9 (14.06)	7.5 (15.8)	6.7 (15.0)	50.3
Contaf 5 EC + Calixin 80 EC	100 + 90	9.5 (17.95)	10.4 (18.8)	9.9 (18.3)	63.0	6.4 (14.65)	7.9 (16.3)	7.1 (15.4)	47.4
Control		26.1 (30.72)	27.6 (31.6)	26.8 (31.2)	-	13.6 (21.64)	13.4 (21.4)	13.5 (21.5)	-
LSD (P=0.05)	-	1.88	1.73			0.62	1..63		

The data were transformed to arcsine transformation. Figures in parentheses are the means of original % disease incidence/severity.

superior to untreated check in reducing disease severity.

The two years pooled data (Table 1) reveal that the test fungicide Nativo 75 WG was found to be effective at 125 g/ha to yield 60.0% reduction in disease severity over control and was found statistically superior to its constituents Folicur 250 EW and trifloxystrobin 50 WG at recommended doses. Folicur 250 EW at 250 ml/ha yielded 50.3% disease control, whereas, trifloxystrobin 50 WG at 625 g/ha resulted in 37.0% disease control. Folicur 250 EW at 250 ml/ha was statistically at par with Contaf 5EC + Calixin 80 EC at recommended dose. The results were comparable with the studies carried out by various workers (Venkataram 1974; Thakur and Thakur 2005; Thakur *et al*. 2009). Nativo 75 WG at lower concentrations (75 and 100 g/ha) was found to be least effective to keep the disease pressure below 50%.

No phytotoxicity symptoms (Table 2) such as chlorosis, necrosis and epinasty were observed on juvenile pluckable shoots even at higher concentrations of the fungicide.

Table 2. Phytotoxicity of Nativo 75 WG in tea

Treatment	Dose (g or ml / ha)	Chlorosis	Necrosis	Epinasty
Nativo 75 WG	100	0	0	0
Nativo 75 WG	125	0	0	0
Nativo 75 WG	150	0	0	0

The study conclusively inferred that Nativo 75 WG at 125 g/ha was a promising fungicide to reduce the disease upto 60.0%. It was statistically significant to its constituents Folicur 250 EW and Trifloxystrobin 50 WG at recommended doses. Hence, Nativo 75 WG - a co-ordinate fungicide of trifloxystrobin (meso-systemic) and tebuconazole (systemic) at 125 g/ha is recommended against blister blight of tea to keep disease pressure below 60.0%.

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Short Note

Effect of top working to improve pollination in apple (*Malus x domestica* Borkh.) orchards under mid hill conditions of Kullu district

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Abstract

A study was carried out at village Seobagh of Kullu block located at 5000 feet altitude on eighteen years old Royal Delicious apple orchard raised on seedling rootstock spaced at 6m x 6m apart. Seven pollinizer cultivars *viz*. Golden Delicious, Granny Smith, Spartan, Commercial, Mollis Delicious, Gloster and Black Ban Davis were used in various combinations [viz. $T_{1:}$ Top working with Golden Delicious + Granny Smith, $T_{2:}$ Top working with Golden Delicious + Spartan, $T_{3:}$ Top working with Commercial + Mollis Delicious + Gloster, $T_{4:}$ Top working with Commercial + Black Ban Davis + Spartan and $T_{5:}$ Farmers' practice (Golden Delicious or Red Gold)] to top work the Royal Delicious branches in three different directions during the spring season. Top working with pollinizer cultivars Commercial + Black Ban Davis + Spartan (T_4) gave highest average fruit set (30.19%) and yield (13.85 t/ha) followed by T_3. However, minimum fruit set and yield (16.51%, 9.71 t/ha respectively) of Royal Delicious apple were recorded under farmers practice (Control) i.e. Golden Delicious.

Key words: Top working, pollinizers, apple, fruit set, yield

Apple (*Malus x domestica* Borkh.) is the predominant temperate fruit crop of India which accounts for about 2.8% of total fruit production of the country. India has 5th ranking in the world production of apple (Anonymous 2015). However, the decreasing trend in its productivity in the last decade due to changing climate scenario has caused a serious concern to the fruit growers and planners of the country. In Himachal Pradesh, the productivity of apple varies between 6-7 t/ha as compared to 25-30 t/ha in the developed countries like USA, UK, Australia and Canada. The causes of low productivity of apple are many, but pollination is the major factor which becomes serious especially under adverse climatic conditions. Nearly 75% old Delicious apple orchards have inadequate pollinizer proportion (less than 20%) and suffer with pollination problems (Gautam *et al*. 2004). Such orchards having fruit set problems with inadequate pollinizers can be managed effectively by providing various supplementary techniques such as branch top working of pollinizer scions, pollinizers bouquet, hand pollination, spraying and dusting with pollen particularly under adverse weather conditions. Supplementary pollination arrangements are also necessary because there is lack of diversity in pollinizing cultivars. Mainly Golden Delicious and Red Gold are being predominantly used which have attained biennial bearing tendency. Their bloom seldom coincides with the flowering period of Delicious cultivars. Also bloom of Red Gold is damaged by spring frost. Keeping in view the importance of pollinizer's diversity in enhancing productivity, the present investigation was conducted to investigate the effectiveness of different combinations of pollinizers for increasing production in orchards lacking adequate pollinizers and to select suitable pollinizers with better fruit set responses.

The present investigation was carried out at village Seobagh of Kullu block located at 5000 feet above mean sea level on eighteen - year- old Royal Delicious apple orchard having low proportion of pollinizing trees raised

on seedling rootstock spaced at 6 m x 6 m apart. Seven pollinizer cultivars *viz*. Golden Delicious, Granny Smith, Spartan, Commercial, Mollis Delicious, Gloster and Black Ban Davis were used in various combinations [viz. $T_{1:}$ Top working with Golden Delicious + Granny Smith, $T_{2:}$ Top working with Golden Delicious + Spartan, $T_{3:}$ Top working with Commercial + Mollis Delicious + Gloster, $T_{4:}$ Top working with Commercial + Black Ban Davis + Spartan and $T_{5:}$ Farmers' practice (Golden Delicious or Red Gold)] to top work (by cleft grafting) six branches of each tree in different directions during the Spring season of 2008. The trial was conducted in randomized block design with three replications. Each treatment was constituted of having five trees.

Fruit set was recorded three weeks after petal fall and percent fruit set was calculated by following formula given by Westwood (1993).

Fruit set (%) = Number of fruit set/Number of flowers cluster x 100

Fruit yield was recorded by removal of crop load during harvesting season as kg/tree based on 20 kg standard apple box and later converted to t/ha. The weight of fruit was taken with the help of a top pan balance. The unit sample consisted of ten fruits and the results were expressed as weight in g/fruit. Fruit size (length and breadth) was recorded with the help of Vernier calliper and expressed as cm. Total soluble solids were determined using a hand refractometer.

The top worked branches of main cultivars with pollinizers scion take at least three years to change the vegetative shoots into flower buds, therefore, data were recorded during 2012 and 2013.

Very less number of pollinizer trees have been planted in existing Delicious apple orchards because the predominant pollinizers like Red Gold and Golden Delicious are of low market value. Nearly 70-80% orchards have minimum proportion. The existing pollinizer proportion is given in Table 1. At present 33% pollinizer proportion is recommended for optimum cropping of Delicious but hardly 5% orchards contain this much number.

In all existing grown up apple plantations of Delicious, Golden Delicious and Red Gold were the major pollinizing cultivars (Table 2). Only very few orchards (about 5.0-7.0%) have adequate diversity of pollinizing cultivars and their placement. Moreover these pollinizers have been planted in groups. These arrangements have aggravated the gravity of pollination problem thereby affecting fruit set in Delicious. With the change in climate scenario, most of these pollinizing cultivars have attained the biennial bearing tendency.

Table 1. Existing pollinizer proportion in Delicious apple plantations

Pollinizer proportion (%)	Himachal Pradesh (% orchard)	Uttarakhand (% orchard)	Jammu and Kashmir (% orchard)	Average yield (20 kg boxes)
< 10	42.4	70.0	40.0	1.3
10-20	31.5	20.0	30.0	2.1
20-30	18.5	10.0	20.0	3.3
> 30	7.6	Nil	10.0	5.2

Source: Gautam *et al*. 2004

Table 2. Relative proportion of pollinizing cultivars in Delicious orchards

Pollinizer	Relative proportion (%)
Golden Delicious	30.4
Red Gold	42.4
Tydeman's Early Worcester	20.0
Pippin group (King Pippin, Yellow Newton, Black Ban Davis, Summer Queen, Red June, Early Royal)	7.0

Source: Gautam *et al*. 2004

The data presented in Table 3 showed significant differences among different treatments. Different pollinizer combinations resulted in significantly higher fruit set and yield. Top working of trees with Commercial + Black Ban Davis + Spartan gave significantly higher average fruit set (30.19%) compared to control (16.51%). Commercial + Mollis Delicious + Gloster (28.67%), Golden Delicious + Spartan (23.50%) and Golden Delicious + Granny Smith (19.73%) also resulted in significantly higher fruit set. Similar trend was noticed in case of fruit yield of apple. Commercial + Black Ban Davis + Spartan, Commercial + Mollis Delicious + Gloster, Golden Delicious + Spartan and Golden Delicious + Granny Smith gave 42.63%, 31.82%, 22.55% and 15.24%, respectively, higher yield over control. Effectiveness of supplementary pollination method in apple has also been reported by Jindal *et al*. (1993) and Chauhan *et al*. (2004).

Data pertaining to the quality parameters of apple after top working with pollinizers are given in Table 4. All the quality parameters *viz*. fruit weight, fruit length, fruit breadth and total soluble solids were significantly affected due to pollinizer's combinations. Maximum fruit weight (120.25 g), fruit length (6.54 cm), fruit breadth (6.60 cm) and total soluble solids (13.56 ^{0}B) were recorded from the trees top worked with Commercial + Black Ban Davis + Spartan (T_4) closely followed by the treatments T_3 and T_1 but superior to control.

On the basis of present study, it was concluded that Commercial + Black Ban Davis + Spartan followed by Commercial + Mollis Delicious + Gloster, Golden Delicious + Spartan and Golden Delicious+ Granny Smith are the best pollinizers combinations for apple under mid hill conditions of Kullu district.

Table 3. Fruit set and yield of apple top worked with different pollinizers

Treatment (Top working with)	Fruit set (%)		Pooled	Yield (t/ha)		Pooled
	2012	2013		2012	2013	
T_1: Golden Delicious + Granny Smith	18.25	21.22	19.73	11.14	11.25	11.19
T_2: Golden Delicious + Spartan	22.00	25.00	23.50	11.77	12.04	11.90
T_3: Commercial + Mollis Delicious + Gloster	27.52	29.82	28.67	12.74	12.86	12.80
T_4: Commercial + Black Ban Davis + Spartan	29.54	30.84	30.19	13.64	14.06	13.85
T_5: Control (Golden Delicious or Red Gold)	16.00	17.02	16.51	9.69	9.73	9.71
LSD (P=0.05)	0.14	0.16	0.19	0.09	0.10	0.12

Table 4. Fruit quality of apple (mean of both years) top worked with different pollinizers

Treatment (Top working with)	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Total soluble solids (^{0}B)
T_1: Golden Delicious + Granny Smith	116.00	6.44	6.50	12.70
T_2: Golden Delicious + Spartan	114.25	6.40	6.42	12.30
T_3: Commercial + Mollis Delicious + Gloster	118.30	6.48	6.52	13.00
T_4: Commercial + Black Ban Davis + Spartan	120.25	6.54	6.60	13.56
T_5: Control (Golden Delicious or Red Gold)	105.00	6.18	6.25	12.20
LSD (P=0.05)	5.72	0.10	0.09	0.22

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Short Note

A brief account of women empowerment through self-help groups – A case study

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Abstract

Women form a vital part of India's work force and play a very significant role with in and outside home. The future of mankind is linked to the development of women's potential and their economic independence. An attempt has been made to analyse the status of 40 Self Help Groups (comprised of 446 farm women) from nine villages of Baijnath block of District Kangra (Himachal Pradesh). Data were collected through interviews, discussions and observations. It was found that maximum duration of the groups was three years and majority of them were registered (92.5%) and 82% of them were doing inter-loaning. Women were using this money for general requirements like clothes, cosmetics and grocery items (51%), renovation of house (41.6%), marriage in own family (36.5%), health problems (34.8%). Exposure to outside world (91.3%), confidence among the members (78.8%), economic security (77.5 %) and cooperation among members (73.8%) were the main benefits reported by majority of SHG members. These groups were regular in money collection, maintenance of registers, discussion on utilization of money collected, socialization, discussing the social problems and religious activities during monthly meetings.

Key words: Self Help Groups, SHG, Women Empowerment, Microfinance

Self-Help Group (SHG) is a small voluntary association of poor people, preferably from the same socio-economic background. The people joined together for the purpose of solving their common problems through mutual help. The SHG promotes small savings among its members which are kept either with a bank or post office or cooperative society. This common fund is in the name of the SHG. Usually, the number of members in one SHG does not exceed twenty. The organizations forming the groups train the SHG members for maintaining the accounts on saving, lending, repayments and group functioning. SHGs enhance the quality of status of women as participants, decision makers and beneficiaries in the democratic, economic, social and cultural spheres of life (Jain, 2003). Money in the hands of men is spent quite differently from the one in hands of women. Reddy (2005) observed that the state of SHGs identifies key areas of weakness which undermine the sustainability of SHG movement. He identifies the major areas such as financial management, governance and human resource ranges from weak to average quality for a majority of SHGs. Microfinance is a powerful tool to alleviate poverty and empowerment of rural women. It is effective in bringing social and economic changes in the rural India with improved managerial abilities of women (Pillai and Nadarajan, 2010).

The Government of India, is implementing women's empowerment programme in a big way. Since 1999, the department of Women and Child Development adopted the strategy of social mobilization through formation of small Self Help Groups of women. A systematic study of Self Help Groups is important to understand their strengths and weaknesses, their membership behavior, linkages and overlaps with other institutions. Thus, the present study was carried out to study the operational mechanism of SHGs, their Inter loaning behavior, to know the advantages of SHGs and to investigate the problems faced by the women.

The present study was undertaken in Baijnath block of District Kangra of Himachal Pradesh. A sample of 40 SHGs from nine villages *viz.* Dhanag, Gankhetar, Taragarh, Averi, Kukena, Panjala, Girtholi, Beer and Kyor was randomly selected. A structured interview schedule was prepared after reviewing the literature and discussions with experts. Data were collected from president and secretary i.e. two respondents from each Self Help Group, thus

comprising a total sample of 80 respondents. Information was generated through primary (personal interview and discussions with groups) and secondary sources (records maintained by the groups). Monthly meetings of Self Help Groups were also attended for observations. The data were analyzed in the form of number and percentages.

Table 1. exhibits general profile of sample Self Help Groups**.** There were total 446 members in 40 Self Help Groups. More than half of the groups (55%) were up to 2 years old, 25% three years old, and the rest were just six months old (20%), which involved 53.1, 24.9 and 22.0% of the total women, respectively.

Almost all the groups were registered with banks (92.5%) comprising of 91.9% of total women. The rest of the groups (7.5%) had yet to be registered as their formation time was less than six months (the important condition for registration). As far as size of the groups is concerned, little more than half of them were small sized (42.2% women), followed by medium size groups (30% groups and 30.5% women). Only 17.5% groups were large in size with 16-20 members comprising of 27.4% women. Sixty five percent of the groups containing 63.0% of women were pooling INR 20/month/member, followed by INR 10/month/member (22.5% groups and 25.5% women) and INR 50/month/member (7.5% groups and 11.7% women).

Terms and conditions for inter-loaning were decided by members of the individual group. Almost 58% of the groups were charging 2% interest per month and rest 32% groups with 1% interest per month.

It could be observed from the Table 2. that all the groups were involved in money collection and maintenance of registers, discussions on utilization of collected money and socializing in the group meetings.

About $3/4^{th}$ of the groups were involved in discussing social problems of the area and religious activities. Other activities performed by the groups involved feast party (52.5%), discussion regarding entrepreneurial activities undertaken or to be undertaken (42.5%), cleaning the village through *shramdan* (40%) and visiting places of common interest (32.5%).

Main purpose of forming SHGs was to encourage the habit of saving, boost member's self confidence and improve their self esteem. Out of 446 members 296 were involved in inter loaning. The SHGs were not only involved in money management activities but also in socializing and other common activities. Fig 1. exhibits that members of SHGs as beneficiaries were taking loan for their general requirements (clothes, cosmetics and grocery) (51%), renovation of house (41.6%), marriages (36.5%), health problems (34.8%), renovation of cowshed (24%) and attending functions of friends and relatives (14.5%).

Table 1. General profile of sample self help groups

Characteristics	Number		Percentage	
	SHGs	Members	SHGs	Members
Duration of formation				
Upto 6 months	8	98	20.0	22.0
Upto 2 years	22	237	55.0	53.1
Upto 3 years	10	111	25.0	24.9
Nature of group				
Registered	37	410	92.5	91.9
Non-registered	3	36	7.5	8.1
Size of the group				
Small (upto 10 members)	21	188	52.5	42.2
Medium (11-15 members)	12	136	30.0	30.5
Large (16-20 members)	7	122	17.5	27.4
Contribution (INR)/member/month				
10	9	113	22.5	25.3
20	26	281	65.0	63.0
30	5	52	7.5	11.7
Interest rate (INR/100/month) for inter-loaning				
1	11	120	33.3	40.5
2	19	145	57.6	49.0
5	3	31	9.1	10.5

Table 2. Detail of activities undertaken by Self Help Groups*

Activities Undertaken	Number of Self Help Groups	Percentage
Money collection and maintenance of registers	40	100.0
Socializing	40	100.0
Discussion on utilization of collected money	40	100.0
Discussing the social problems of the area	31	77.5
Religious activities	29	72.5
Tea party	21	52.5
Discussion regarding entrepreneurial activities	17	42.5
Cleaning the village with *shramdan*	16	40.0
Visiting different places of common interest	13	32.5

*Multiple Responses

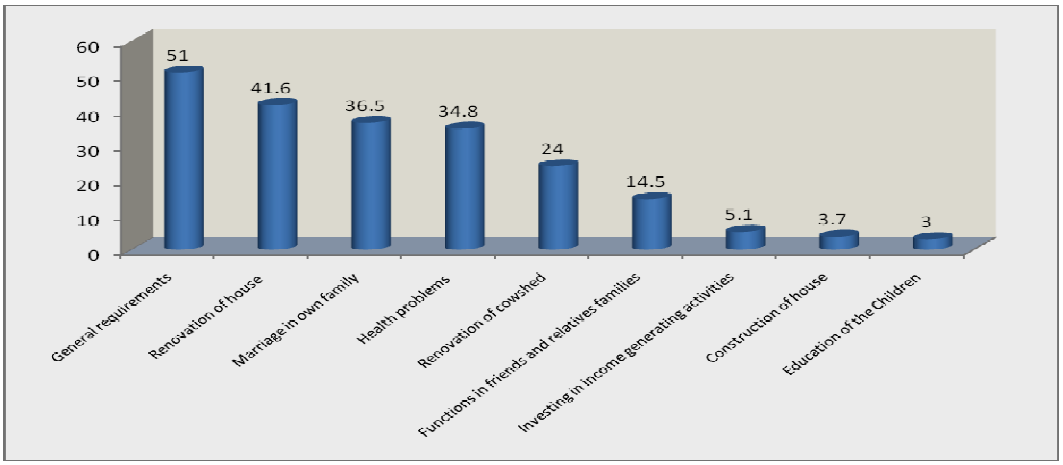

Fig 1. Purpose of taking loan by the members

A meager percentage of members (3-5%) had also taken loan to invest in some income generating activity, construction of house and education of children.

Advantages of Self Help Groups

Rural women in India suffer from being both economically and socially invisible. Through SHGs they are organized to overcome such problems. There were many advantages of being members of SHGs reported by the office bearers of groups which included 'exposure to outside world' (91.3%), 'confidence among members' (78.8%), 'financial security' (77.5%) and 'cooperation among members '(73.8%) (Table 3). Other advantages reported by some respondents include 'special recognition to the village' (23.8%) and 'availing benefits from the government schemes' (16.3%).

Association with SHGs made the members aware of the gender equality and led them to economic, social and political independence. It also improved the position of the respondents in the patriarchal family system through gaining knowledge of legal system and enabled the members to involve in family decision making. Moreover, the members also developed the leadership qualities through sense of devotion to work, duty consciousness and self confidence (Chitagubbi *et al.* 2011).

Table 3. Advantage of SHGs according to the office bearers of the group *

N=80

Advantages	Number	Percentage
Exposure to outside world	73	91.3
Confidence among the members	63	78.8
Economic security	62	77.5
Cooperation among members	59	73.8
Recognition to the village	19	23.8
Benefits from government schemes	13	16.3

*Multiple Responses

Problems in running SHGs

Although most of the groups in study area were running smoothly, still a few of them had problems either with group members or due to their families. The office bearers i.e. president and cashier were interviewed to know the problems faced by them as they were holding responsibility of managing the group activities smoothly.

Conflicts among the group members (18.6%) and collection of money (12.5%) and assembling the members (10.0%), were the main problems reported by office bearers (Fig 2.). Other problems faced were difficulty in money distribution (7.5%) and conflicts at home (6.3%). Sharma (2007) reported that the SHG movement has not achieved success in some north-eastern states for reasons that are peculiar to the region. The study also highlighted the banking constraints as a factor that hinders the quality of SHG in Northeast India. However, such type of problems has not been encountered by the Self Help Groups of the study area.

It is concluded that most of the SHGs were registered. Half of them were having up to 10 members. SHGs members were using money for their general requirements, renovation of house, marriages in home and for health purposes. The main activities of members during monthly meetings were money collection, maintenance of registers, discussion on utilization of money collected, socialization, discussing the social problems and religious activities. Exposure to outside world, confidence in handling money, economic security and co-operation were the main benefits reported by majority of SHG members.

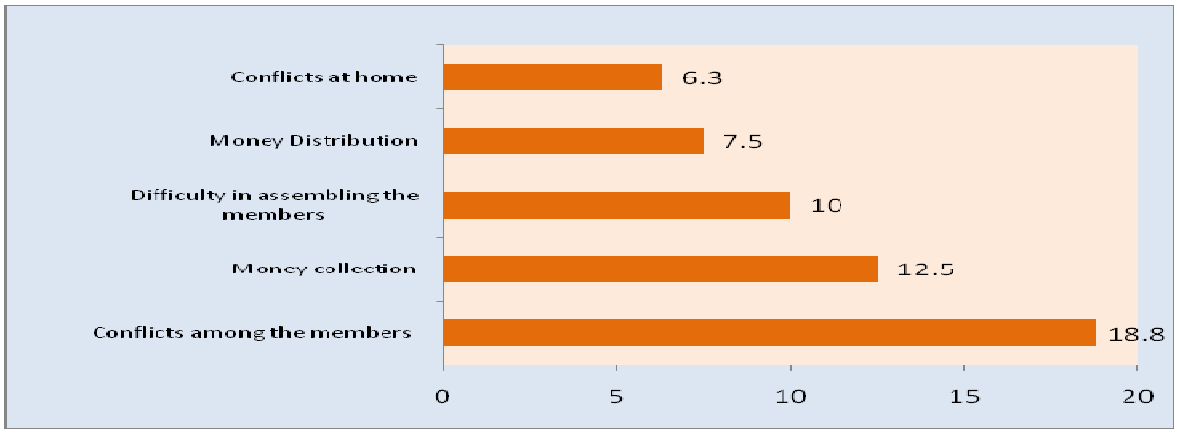

Fig 2. Problems in running the Self Help Groups (%)

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Short Note

Studies on causes and consequences of skewed child sex ratio

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Abstract

The present study was conducted to identify the causes and consequences of skewed child sex ratio in Kangra district of Himachal Pradesh. A total sample of 100 respondents (married women i.e. 50 rural and 50 urban, aged 18 to 45 years) was taken from Kangra tehsil of Kangra district. The respondents were selected on the basis of simple random sampling from two villages (Birta and Kholi) and two wards (4 and 8) from the area. They were interviewed through an interview schedule containing both open and close ended questions. The data were coded, tabulated and analyzed through SPSS (Statistical Package for Social Sciences). The results revealed that 86% respondents were well aware of the skewed child sex ratio in the State. Most of them (58.08%) blamed foeticide as the major cause behind it. Respondents felt that it could lead to various consequences but the worst one was stoppage of family lineage (33.97%).

Key words: Skewed child sex ratio, causes, consequences, foeticide

Two decades have passed since Sen (1990) mooted the notion of 'missing women' in his seminal article, wherein he noted that more than 100 million women were missing across South Asia, West Asia, North Africa and China. In India, the widening gap in the male to female ratio is highlighted by census after census. This is particularly pronounced in the age group of 0-6 years. The 2011 Census of India sparked off a bigger debate on the issue by highlighting the changes in the child sex ratio across the nation. A drastic decline in child sex ratio was recorded in Punjab, Haryana, Himachal Pradesh, Gujarat, Maharashtra, Arunachal Pradesh and Uttrakhand and Union Territories of Chandigarh and Delhi during 1981-2001.

There has been consistent decline in child sex ratio ever since Himachal Pradesh attained Statehood in 1971. In Himachal Pradesh, from 981 in 1971, the child sex ratio fell to 896 in 2001. Although, the Census of 2011 has shown a marginal improvement of 13 points but is not sufficient to meet the drastic decline of 55 points in 2001 Census. This decline, in itself, is not very momentous and could be ascribed to various extraneous factors. However, when it is accompanied by a sudden drastic decline in the child sex ratio, one is forced to pause and think about the causes and consequences for the State as a whole.

The purpose of the present study was to identify the major causes for the skewed child sex ratio (0-6 years) in Kangra district (which has the child sex ratio of 876 and among one of the very low child sex ratio districts in the country) of Himachal Pradesh and to identify its consequences and to arrive at logical conclusions on the basis of this study.

The study was conducted in Kangra tehsil of Kangra district which has the child sex ratio of 859. Two villages namely Birta and Kholi having child sex ratio 777 and 735, respectively, and two wards namely ward 4 and ward 8 having child sex ratio 750 and 538 were selected. A sample of 100 married women (50 rural and 50 urban) aged between 18 to 45 years was taken. The respondents were selected on the basis of simple random sampling. The data were collected by using an interview schedule containing

both open and close ended questions specially designed for the purpose. The coded data were processed through computerized statistical package for the social sciences and tabulated. The tabulated data have been interpreted and the analysis has been done to meet the objectives of the study and to reach at logical conclusions.

It is evident from the data (Table 1) that 86% of the respondents were aware of the fact that the number of girls (0-6 years) in Himachal Pradesh was less than that of boys. They stated that they got this information through newspapers, TV/radio and from relatives and friends. On the other hand, 14% of them were not aware of the fact. The present study agrees with Prasad (2012) who observed that the Census of 2011 has recorded the lowest decline in sex ratio of 914 in 0-6 years with 3 million missing girls from 78.8 million in 2001 to 75.8 million in 2011.

Table 2 depicts the causes of skewed child sex ratio. Most (58.08%) of the respondents (both rural and urban) said that foeticide was one of the major causes of skewed child sex ratio. They stated that when God did not bless some parents with a son, they, at the time of next pregnancy, adopted sex-determination techniques to check the sex of the unborn foetus. On the other hand, 16.91% blamed one male child norm for it. A similar finding was revealed by John *et al.* (2009) who highlighted that the practice of sex selective abortions was the major cause of decline in sex ratio in Himachal Pradesh, Haryana and Punjab. Their study observed that most of the people prefer small families which result in selective elimination of female foetuses.

Although, 12.5% respondents said that poor medical care was the cause of declining child sex ratio, they stated that some parents neglected the health of girl children from early childhood during their illness because they believed that girls were genetically stronger and got cured naturally. Malnutrition was held to be the cause of skewed child sex ratio by 7.36% respondents. They said that some parents neglected their girl children right from birth. They were less breastfed (for less than 3 months) with wider gaps between daily feeds and given poor quality, left over and lesser food to eat. They added that malnutrition badly affected their physical and mental development. Table 3 indicates the perception of the respondents regarding the possible consequences of the skewed child sex ratio. An adverse sex ratio can have devastating consequences for society. Such consequences are clearly revealed by many scholars in their studies. Ghosh *et al*. (2005), in their study, disclose that increased female foeticide and decline in sex ratio would lead to non-availability of brides, stoppage of family lineage, rise in sexual violence against women, lack of female workforce and polyandry. In India, the absolute numbers of missing females is likely to grow in future, which is likely to impact the marital status of males. The present study also reaches the same conclusion that most of the respondents (33.97%) believed that it could lead to stoppage of family lineage because many boys would remain unmarried and childless so the family lineage would automatically end. On the other hand, 21.69% of the respondents believed that it could increase crimes against women. Moreover, 17.46% believed that it would result in the handicapping of household work and cooking because females could handle these tasks perfectly. However, 16.03% of the respondents believed that it could lead to polyandry. Some respondents cited the case of *Draupadi* of *Mahabharat* who was married to five *Pandavas*. Another 8.43% stated that decline in child sex ratio would eliminate the socio-cultural festivals such as *Rakhi* and *Bhai Dooj* because when parents will stop giving birth to daughters, the festivals related to brothers and sisters will also end.

Table 1. Distribution of respondents according to knowledge regarding the skewed child sex ratio in HP

Response	Kangra Tehsil		Total
	Rural N=50	Urban N= 50	Rural + Urban N= 100
Yes	41 (82.0)	45 (90.0)	86 (86.0)
No	9 (18.0)	5 (10.0)	14 (14.0)

Figures in parenthesis denote percentages

Table 2. Opinion of respondents regarding the causes of skewed child sex ratio

Causes	Kangra Tehsil		Total
	Rural N=61	Urban N= 75	Rural + Urban N= 136
Foeticide	34 (55.74)	45 (60.0)	79 (58.08)
One male child norm	8 (13.11)	15 (20.0)	23 (16.91)
Poor medical care	9 (14.76)	8 (10.67)	17 (12.5)
Malnutrition	4 (6.55)	6 (8.0)	10 (7.36)
Do not know	6 (9.84)	1 (1.33)	7 (5.15)

Figures in parenthesis denote percentages

Table 3. Distribution of respondents according to opinion about possible consequences of skewed child sex ratio in Kangra tehsil

Opinion	Rural N=108	Urban N=104	Rural+Urban N=212
Stoppage of family lineage	40 (37.03)	32 (30.77)	72 (33.97)
Crimes against women will increase	15 (13.89)	31 (29.80)	46 (21.69)
Impact household work and cooking	24 (22.23)	13 (12.5)	37 (17.46)
Polyandry	13 (12.03)	21 (20.19)	34 (16.03)
Negative impact on socio-cultural festivals	10 (9.26)	6 (5.77)	16 (7.55)
Do not know	6 (5.56)	1 (0.97)	7 (3.30)

Figures in parenthesis denote percentages

In conclusion, it can be said that skewed child sex ratio would lead to an enormous economic and social loss for the nation. The road is difficult and cannot be traversed by women alone. Equal male participation is a must to break the shackles of patriarchy and lead to the emergence of a society in which true equality prevails and in which girls are valued and regarded as equal partners in development.

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Short Note

Evaluation of different rootstocks for bacterial wilt tolerance in bell pepper [*Capsicum annuum* (L.) var. *grossum* (Sendt.)] under protected conditions

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Abstract

Bell pepper (*Capsicum annuum* L. var. *grossum* Sendt.) is an important commercial crop grown under protected condition in Himachal Pradesh. Being long duration under protected environment, it is the principle money spinner off-season crop. Production of bell pepper under protected conditions in the state is very low as compared to the National and International levels because of lack of suitable Cultivars and hybrids resistant to bacterial wilt. Among biotic stresses bacterial wilt caused by *Ralstonia solanacearum* is the most devastating disease under protected as well as open field conditions in mid hills of HP which reduces yield of capsicum to very low levels. Numerous attempts have been made to develop bacterial wilt resistant varieties, but till date no resistant hybrid is available. The best option to overcome this problem is grafting scions of horticulturally superior hybrids on resistant rootstocks. The study revealed that chilli rootstock PI-201232 was the most suitable bacterial wilt resistant rootstock of bell pepper whereas; brinjal rootstocks were not suitable for bell pepper scions.

Key words: Bell pepper, grafting, rootstock, scion, bacterial wilt, protected cultivation

Polyhouse technology is becoming popular in Himachal Pradesh and a large number of polyhouses are being constructed at farmer's fields. The geographical conditions of the state are quite suitable for cultivation under protected conditions, due to prevalence of near optimum growing climatic conditions. Among vegetable crops, bell pepper (*Capsicum annuum* L. var. *grossum* Sendt.), is the most widely grown off-season crop under polyhouse conditions in Himachal Pradesh. It is cultivated on an area of 2240 ha with production of 39500 MT and productivity of 17.63 MT/ha in HP under open field conditions, whereas area under polyhouse conditions is approximately 300 ha (Anonymous 2013). Vegetable production and productivity is very high under protected environments as compared to open field conditions. But production of bell pepper under polyhouse conditions in HP is very low as compared to national and international levels.

Bell pepper production in Himachal suffered a great setback due to biotic and abiotic stresses. Among biotic stresses bacterial wilt caused by *Ralstonia solanacearum* is the most devastating disease under protected as well as open field conditions in mid hills of HP which reduces capsicum yield to very low levels. Lack of bacterial wilt resistant cultivars and hybrids is the main reason for low production under polyhouse conditions in Himachal Pradesh. The disease was first reported in Kangra valley in 1981 on solanaceous crops, and it remained sporadic in nature till 1985, and now it has become endemic in Kangra and Mandi districts (Sood and Singh, 1992). Numerous attempts have been made to develop bacterial wilt resistant varieties, but till date no source possessing resistance is available. In order to combine various desirable horticultural traits in capsicum along with resistance to diseases, the best strategy to combat bacterial wilt is grafting of desirable scion with resistant rootstocks.

Grafting is an environment-friendly alternative method to control bacterial wilt. Grafting scions on resistant rootstocks makes it possible to control soil borne diseases and increase yield of susceptible cultivars (Lee and Oda, 2003). Grafting of vegetable seedlings in India is still in infancy due to lack of knowledge, awareness and non-identification of resistant rootstocks. This technology was ignored because the focus of the breeders remained only to develop suitable varieties or hybrids resistant to biotic stresses. Since grafting gives increased disease tolerance and vigour to crops so it will be useful in the low-input sustainable horticulture of the future.

The present investigation was carried out at Palampur during 2014 using five rootstocks of chilli and three of brinjal plus one control (non grafted plots of hybrid Indra). Commercial hybrid 'Indra' was used as a scion. The seeds of different rootstocks were procured from different sources. Some rootstocks were imported from AVRDC- Taiwan while others were the locally identified resistant to bacterial wilt (Table 1). The nursery of different rootstocks was raised in disposable cups whereas, nursery of scion was raised in plug trays by using soil-less media having mixture of cocopeat: perlite: vermiculite :: 3:1:1 on 10th January, 2014 in growth chamber. Grafted seedlings were transplanted on 17th April 2014. Ten plants of each treatment were planted at inter row distance of 45 cm and plant to plant distance of 30 cm by using black polythene (30 micron thick) mulch of one meter width. Eight rootstocks and one control (non grafted) were planted in Randomized Block Design with three replications in 250 m^2 modified naturally ventilated quonset polyhouse. Observations were recorded on five randomly selected plants in each plot *viz*., days to first flowering, days to first harvest, number of marketable fruits per plant, average fruit weight (g), marketable fruit yield per plant (kg)**,** marketable fruit yield per square metre (kg)**,** fruit length (cm), fruit width (cm), harvest duration (days)**,** plant height (cm) and bacterial wilt incidence (%). Screening of rootstocks against bacterial wilt *(Ralstonia solanacearum)* was done. TZC broth specific for *Ralstonia solanacearum* was prepared and bacterial culture was taken from Department of Plant pathology. Then the culture was inoculated in broth and broth was kept in incubator for 1 hr. Soil was inoculated with *Ralstonia* culture and then different rootstocks were transplanted in different pots containing sick soil. After one month it was recorded that all the rootstocks were resistant to bacterial wilt. The observations were recorded on bacterial wilt incidence at weekly intervals under protected conditions. The data regarding above mentioned characters were averaged and subjected to analysis of variance (Panse and Sukhatme, 2000).

Table 1. List of Rootstocks

Rootstocks	Source
Pant C-1 (Chilli)	GBPUAT- Pantnagar-India
Surajmukhi (Chilli)	CSKHPKV- Palampur-India
VI-37556 (Chilli)	AVRDC- Taiwan
PI-201232 (Chilli)	AVRDC- Taiwan
AVPP0205 (Chilli)	AVRDC- Taiwan
VI-045376 (Brinjal)	AVRDC- Taiwan
VI-047335 (Brinjal)	AVRDC- Taiwan
VI-034845 (Brinjal)	AVRDC- Taiwan

Different rootstocks under study significantly affected the number of days to flowering in capsicum (Table 2). Rootstock PI-201232 (RS4) took minimum number of days (48.79) to produce first flower. The other rootstocks of chilli were also superior to control (non-grafted) which took 52 days to produce first flower. Rootstock RS8 (VI-034845) took maximum days (53.05) for first flowering. Rootstock PI -201232 (RS4) took 4.26 days less than VI-034845 (RS8). Rootstock Pant C-1 (RS1) and Surajmukhi (RS2) took 49.73 and 49.78 days to reach flowering which were statistically at par with each other. In grafted plants the movement of endogenous flowering substances across the graft union is easy. The early flowering in grafted plants may be due to better and improved root system of the rootstocks used, which has resulted in increased water and nutrient uptake. These results are in conformity with the findings of Ibrahim *et al*. (2014). Rootstock PI-201232 was observed to produce marketable fruits in minimum (73) days which were statistically superior to all other rootstocks used in the study. It was also amply clear from the data that days to first harvest ranged from 73.00 to 80.49 days. The early harvest in grafted plants may be due to the compatibility of various physiological traits such as photosynthetic rate, nutrient use efficiency, proper water flow and hormonal response which also influenced plant growth and biomass production. The results are in line with the findings of Khah *et al*. (2006), Gisbert *et al*. (2010) and Ibrahim *et al*. (2014). Rootstocks significantly affected the number of fruits per plant. Rootstock RS4 (PI-201232) produced maximum number of fruits per plant (24.70) followed by RS5 (AVPP0205) and RS3 (VI-37556). The other chilli rootstocks were also significantly superior over control (8.56 fruits/plant). In vegetable crops grafting scion over vigorous rootstock improves cytokinin content in scion and improves fruit load on the plant. Similar

Table 2. Effect of different rootstocks on horticultural traits under protected environment

Rootstocks	Days to flowering	Days to harvest	Fruits/ plant (No.)	Fruit weight (g)	Fruit/plant (kg)	Yield (kg/ m^2)	Fruit length (cm)	Fruit width (cm)	Harvest duration (days)	Plant height (cm)
Pant C-1 (RS1)	49.73	77.60	14.13	93.16	1.30	4.32	8.29	7.29	150.53	125.88
Surajmukhi (RS2)	49.78	74.67	20.93	93.73	1.83	7.95	8.13	7.31	159.10	145.51
VI-37556 (RS3)	51.69	77.22	21.17	94.62	1.97	8.37	7.93	7.08	146.97	137.85
PI-201232 (RS4)	48.79	73.00	24.70	99.73	2.47	9.89	8.37	7.51	160.99	160.44
AVPP0205 (RS5)	49.81	75.67	21.20	95.73	1.91	9.03	8.52	7.17	151.20	148.81
VI-045376 (RS6)	52.25	79.68	8.27	90.75	0.72	1.44	7.74	6.52	145.23	113.92
VI-047335 (RS7)	52.40	80.49	8.11	87.40	0.51	0.51	7.63	6.25	146.14	110.35
VI-034825 (RS8)	53.05	80.07	8.26	88.95	0.55	1.00	7.66	6.35	144.61	112.61
Control	52.00	79.00	8.56	91.88	1.17	2.50	7.93	6.70	150.30	127.77
CD (0.05)	0.39	0.73	0.48	0.94	0.15	0.27	0.05	NS	0.11	0.87

findings were also reported by Khah *et al*. (2006), Gisbert *et al*. (2010), Djidonou *et al*. (2013) and Fernandez *et al*. (2013). The treatment RS4 (PI-201232) produced maximum average fruit weight (99.73 g), followed by RS5 (AVPP0205) (95.73 g/plant. All chilli rootstocks were significantly superior to control (91.88 g). The rootstock-scion interaction influences the uptake of minerals, water relations which ultimately led to increased average fruit weight of the grafted plants. The above findings are supported with the conclusions drawn by Khah *et al*. (2006), Davis *et al*. (2008), Djidonou *et al*. (2013) and Fernandez *et al*. (2013). Maximum fruit yield per plant (2.47 kg) was recorded under the rootstock RS4 (PI-201232). All five chilli rootstocks were significantly superior to control (1.17 kg) followed by RS3 (VI-37556) and RS 5 (AVPP0205). The highest yield in grafted plants may be due to resistance to soil borne diseases, water and nutrient uptake, enhancement of vigour, strong root systems, tolerance of low soil temperature and increased photosynthesis. The findings of Lee (1994), Attia *et al*. (2003), Kacjan Marsic and Osvald (2004), Davis *et al*. (2008b) and Voutsela *et al*. (2012) corroborate the above results. Data from table manifested that in case of rootstocks, the mean performance ranged from 0.51 to 9.89 kg. Maximum yield per square meter was observed in plants with rootstock PI-201232 (9.89 kg) followed by AVPP0205 (9.03 kg) and VI-37556 (8.37). All the five chilli rootstocks were found significantly superior over the control (2.50 kg/m^2). The higher marketable yield recorded with grafting was mainly due to an improvement in water and nutrient uptake. These results are in conformity with the findings of Jang *et al*. (2008), Kubota *et al*. (2008), Ballesta *et al*. (2010) and Saadoun and Allaagui (2013).

Among rootstocks AVPP0205 (RS5) was found to record 8.52 cm longer fruits followed by PI-201232 (RS4) (8.37 cm). All the chilli rootstocks were significantly superior to control (7.93 cm). Rootstocks affected fruit length and it may be due to changes in the concentration of growth regulators induced by the rootstock. Similar findings were reported by Gisbert *et al*. (2011a) and Jang *et al*. (2012). Effects of rootstocks on fruit width were found to be non-significant and these results are in line with the findings of Turkmen *et al*. (2010) and Gisbert *et al*. (2011). Harvest duration ranged from 144.6 to 161.0 days. RS4 (PI-201232) resulted in maximum days (160.99) to harvest, followed by RS 9 (Surajmukhi) (159.1 days). The prolonged harvest duration observed may be due to the rootstock with strong root system which supported a long season crop along with improved resistance to various diseases. The findings of Lee (1994) and King *et al*. (2010) corroborate the above results.

Maximum plant height of 160.44 cm was recorded in RS4 (PI-201232) followed by RS5 (AVPP0205) (148.81 cm). All the five chilli rootstocks were found significantly superior to the control (127.77 cm). The reasons for taller plants may be due to indeterminate growth habit of rootstock, increased nutrient uptake and resistance to bacterial wilt incidence. Khah *et al*. (2006), Passam *et al*. (2005) and Marin *et al.* (2013) also reported similar results.

Weekly record on bacterial wilt incidence showed that only non-grafted (control) plants i.e. Indra showed wilting symptoms while all the rootstocks were resistant to bacterial wilt. Therefore, less survival rate of control /non grafted plants was due to the incidence of bacterial wilt.

Therefore, from this study it may be inferred that grafting can be an effective strategy to manage bacterial wilt incidence in chillies.

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