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Effect of Pollination on Cucumber (*Cucumis sativa* L.) Production in Chitwan, Nepal

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Abstract

An experiment was conducted to evaluate the effect of pollination treatments on the production of cucumber in Chitwan district, Nepal. The experiment was carried out in a randomized complete block design from March to June, 2013 and the treatments were: i) Apis cerana pollination, ii) Apis mellifera pollination, iii) hand pollination, iv) open pollination, and v) no pollination (caged), replicated four times. The findings showed positive influence on yield and yield components of cucumber by Apis pollination. Plant growth and number of branches were significantly highest in caged plots. Fruit length, diameter and weight were better in Apis pollination, with the best pollination by Apis cerana. Number of fruit and yield was higher in A. cerana pollination while fruit deformity was 100 percent in caged plots. The seed number per fruit was significantly higher on A. cerana pollination. Therefore, A. cerana pollination on cucumber is imperative to exploit the yield potential of cucumber.

Keywords: *Apis cerana*, *Apis mellifera*, cucumber, pollination

1. Introduction

Cucumber (*Cucumis sativa* L.) is a widely cultivated summer vegetable crop in the gourd family Cucurbitaceae. It is a monoecious annual climber that has been cultivated for more 3,000 years and is still widely cultivated today (Adetula and Denton, 2003). Flowering phenology of cucumber ensures better cross pollination, as it produces male and female flowers separately on the same plant at different internodes. The ratio of male to female flower is 15:1. The pistillate and staminate flowers arise singly from different internodes and open on the same day but, the male flowers are borne first, a fortnight earlier than the female flowers. The female flower borne on ovary, i.e. inferior ovary, and the stigma is receptive throughout the day, while the size of pollen is large and they are sticky (Lauria and Fred, 1995). Therefore, in male flowers, anther dehisces when the corolla expands but the pollens remain on the anther as a sticky mass. The maximum pollination occurs in the forenoon. Female flower closes in the afternoon and never reopens whether or not pollination has taken place; furthermore, the highest percent of fruit set results from deposition of pollen on the stigma between 09:00 a.m to 12:00 noon (Bailey, 1949). Cervancia and Bergonia

(1991) reported that 75 and 58 percent fruit set was obtained in cucumber in bee and open-pollinated plants, respectively, and these were significantly higher than the non-pollinated plant which was only 33 percent. Bee pollination and open pollination produced heavier and uniform fruits. One honeybee colony per acre increased yield by 39 percent as compared to fields without bees (Steinhauer, 1971). Hence, the impact of cross pollination on cucumber productivity definitely depends upon on the extent to which the crop can be pollinated. If crop pollination is managed, a new dimension will be added to increase yield and improve quality, and the area under these crops could be expanded substantially.

2. Materials and Methods

The experiment was conducted in a randomized complete block design (RCBD) with 5 treatments and 4 replications in Gitanagar, Chitwan, Nepal from March to June 2013. The treatments were: i) *Apis cerana* F. pollination, ii) *A. mellifera* L. pollination, iii) hand pollination, iv) open pollination, and v) no pollination (caged with mosquito net). The plot size was 4 m x 2.7 m. The cucumber variety Bimal was seeded @ 2 kg ha^{-1} (2 seeds/pit), for which pit size of 20 cm x 30 cm was dug out spacing at 1 m x 0.9 m fortnight before cucumber planting. Compost was used @ 30 t ha^{-1}, i.e. 2 kg/pit and NPK @ 140:40:100 kg ha^{-1}. Di-ammonium phosphate and muriate of potash were applied as basal application and urea in split dose, which was top dressed 25 days after sowing. Bamboo and jute string were used for staking. Neemix 2 ml liter^{-1} was applied at seedling stage to control red pumpkin beetle. Irrigation was applied as per requirement. Fruits were harvested at weekly interval. Two fruits per plot were left up to maturity.

All the plots were caged with mosquito net of size 5 x 3 x 7 m^3 except a plot in each block which was left for open pollination. Each plant of the treatment with hand pollination was caged with mosquito net. Colonies of honeybee having 3 frames bees, i.e. one *Apis mellifera* hive per replication and one *A. cerana* hive per replication were placed separately inside the cage when cucumber plant started flowering. Honeybee was fed with sugar syrup (1:1) and artificial pollen. Caging was done at 5-10 percent flowering to 90 percent of flowering. Data were collected from 3 plants per plot.

3. Results and Discussion

The caged plots without pollinator had maximum branches (14.5 branches/plant), which was statistically significant from the rest of the treatments (Table 1). The plant height was the shortest on *Apis cerana*-pollinated plots (306.8 cm). Caged plants without pollinators were significantly taller (443.6 cm), which was followed by hand-pollinated plants (386.7 cm). Open-pollinated plants and *A. mellifera*-pollinated plants were statistically similar (Table1). The results clearly indicated that vegetative growth was higher in the plants which were not pollinated. They had less number of fruits and smaller sized fruits.

Table 1: Effect of pollination on number of branch/plant and plant height of cucumber at Gitanagar, Chitwan, Nepal, 2013

Treatment	Branch/plant*	Plant height (cm)*
Apis cerana pollination	10.25^{b}	306.8^{c}
Apis mellifera pollination	11.00^{b}	343.9^{bc}
Hand pollination	11.75^{b}	386.7^{ab}
Open pollination	12.00^{b}	345.7^{bc}
No pollination (caged)	14.50^{a}	443.6^{a}
CV (%)	13.09	12.06
LSD	2.399	67.88
SE	0.7786	22.03

*Means followed by the same letters in a column are not significantly different by DMRT at ≤0.05 level

Apis cerana-pollinated fruits were superior to other treatments and *A. mellifera*- pollinated fruits (5.525 cm) was at par with open (5.008 cm), *A. cerana* (5.930 cm) and hand-pollinated fruits (5.008), i.e. open-pollinated fruit diameter was followed by hand- pollinated fruits (4.247 cm). The lowest diameter was measured in caged plants without insect pollinators (2.825 cm) (Table 2).

Fruit length was superior in both *A. cerana*- (22.05 cm) and *A. mellifera*-pollinated plants (21.27 cm) as compared to other treatments. This was flowed by open pollinated fruits (18.48 cm) and hand pollinated fruits (15.48 cm). Caged plots without pollination resulted in the inferior fruits with the lowest length which is presented in table 2.

Fruit weight was significantly highest on the *A. cerana* pollinated plants (568 g), followed by *A. mellifera*-pollinated plants (515.3 g). Hand pollinated fruits had significantly lower weight (246.5 g) than open-pollinated fruits (365.4 g). The most inferior fruit was non-pollinated one with only 81 g weight (Table 2).

The present results are in accordance with the findings of Gingras et al. (1999), who reported that circumference of cucumbers fruit was correlated positively with pollination of honeybees (*A. mellifera*). Kauffeld and Nelson (1982) obtained the longer size cucumber from the plots pollinated by *A. mellifera* L. as reported by Gingras et al. (1999). *A. cerana* was superior to *A. mellifera*, which might be due to the well adopted native bees with longer foraging hours. Chauta-Mellizo et al. (2012) observed increased fruit mass, size and diameter in *Physalis peruviana* compared to manual and self-pollination.

Flowers that produced fruits were associated with higher number of visits by honeybees. The results of the present investigations further revealed that flowers in caged without bees that received zero visits did produce negligible amount of cucumber. This might be due to auto pollination as reported by Jenkins (1942) who stated that very less percentage of auto pollination could occur in the absence of insects in cucumber.

Table 2: Effect of pollination on fruit diameter, length and weight of cucumber at Gitanagar, Chitwan, Nepal, 2013

Treatments	Diameter of fruit (cm)*	Length of fruit (cm)*	Weight per fruit (g)*
Apis cerana pollination	5.930[a]	22.05[a]	568[a]
Apis mellifera pollination	5.525[ab]	21.27[a]	515.3[b]
Hand pollination	4.247[c]	15.48[c]	246.5[d]
Open pollination	5.008[b]	18.48[b]	365.4[c]
No pollination (caged)	2.825[d]	11.15[c]	81[e]
CV (%)	8.82	8.08	9.35
LSD	0.6390	2.202	51.18
SE	0.2074	0.7145	16.61

*Means followed by the same letters in a column are not significantly different by DMRT at ≤0.05 level

The maximum number of fruit was harvested from the *A. cerana* pollinated plants (6.355/plant) and *A. mellifera* pollinated plants (5.977/plant). This was followed by openpollinated plants (4.020/plant). Nogueira and Calmona (1993) also reported that honeybee (*A. mellifera*) constituted 82.6 percent of visitors to cucumbers flower and showed that plots netted with bees yielded more fruits/m^2 with heavier and higher quality than other plots (open and covered without bees).

Yield was significantly highest (40 t ha^{-1}) in *A. cerana*-pollinated plot followed by *A. mellifera*-pollinated plot (34.32 t ha^{-1}). Open-pollinated plot yielded about 16.5 t ha^{-1} and hand-pollinated yielded less than 6 t ha^{-1}. Caged plants without pollinators yielded only about 0.25 t ha^{-1} (Table 3).

Table 3: Effect of pollination on fruit number and yield of cucumber at Gitanagar, Chitwan, Nepal, 2013

Treatments	Number of fruits/plant*	Yield (t ha^{-1})*
Apis cerana pollination	6.355^{a}	40.13^{a}
Apis mellifera pollination	5.977^{a}	34.32^{b}
Hand pollination	2.142^{c}	5.861^{d}
Open pollination	4.020^{b}	16.12^{c}
No pollination (caged)	0.1225^{d}	0.2560^{e}
CV (%)	11.19	13.36
LSD	0.6427	3.980
SE	0.2086	1.292

*Means followed by the same letters in a column are not significantly different by DMRT at ≤0.05 level

Apis cerana- and *A. mellifera*-pollinated plants had 440.3 and 428.8 seeds per matured fruit, respectively. Open-pollinated cucumber consisted of 388.8 and hand-pollinated plants had 309.5 seeds per matured fruit (Table 4). Honeybee pollination favors the competition and selection of higher quality pollen grains (Winsor et al., 2000), and hence increase seed set (Cowan et al., 2000; Winsor et al., 2000; Al-Ghzawi et al., 2009). Chauta-Mellizo et al. (2012) reported that amount of or manner in which pollen deposited on stigmas by bees increased the number of successfully fertilized ovules which led to higher seed set.

Table 4: Effect of pollination on seeds and deformed fruits at Gitanagar, Chitwan, Nepal, 2013

Treatments	Seed number /fruit*	Deformed fruit (%)*
Apis cerana pollination	440.3^{a}	6.122^{d}
Apis mellifera pollination	428.8^{a}	11.05^{d}
Hand pollination	309.5^{c}	60.55^{b}
Open pollination	388.8^{b}	27.53^{c}
No pollination (caged)	0.000^{d}	100^{a}
CV (%)	5.56	9.32
LSD	26.87	5.893
SE	8.721	1.912

*Means followed by the same letters in a column are not significantly different by DMRT at ≤0.05 level

In case of caged plants without pollinators, all fruits harvested were deformed. This was followed by hand-pollinated plants (about 60% deformed). Open-pollinated plants had more than 27 percent of deformed fruits. The minimum deformed fruits were observed in *A. cerana* pollinated plants. The fruits were misshapen unless the adequate number of pollinator visited the flowers. Beste et al. (1999) reported that fruit enlargement is promoted by growth stimulating hormones and they are produced by developing seeds. They noted that the hormones are provided from the pollen placed to the stigmas in seedless varieties of watermelon.

4. Conclusion

Apis Cerana followed by *A. mellifera* was the most efficient pollinator under field conditions and therefore, its management during cucumber growing season is imperative for higher and quality cucumber production.

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Phenological and Stability Performance of Spring Wheat Genotypes under Rainfed Conditions in Warm Humid Environment of Nepal

R.R. Puri*, N.R. Gautam, S.R. Upadhyay and D. Bhattarai

Abstract

About 25 percent of total wheat area in Terai of Nepal falls under rainfed and partially irrigated conditions. A coordinated varietal trial was conducted during two consecutive crop cycles (2011-12 and 2012-13) under timely sown rain-fed as well as irrigated conditions of terai. The trial was conducted in Alpha Lattice design with two replications at the National Wheat Research Program, Bhairahawa and Regional Agriculture Research Station, Nepalgunj. Observations were recorded for yield and yield traits and analyzed using statistical software Cropstat 7.2. The combined analysis of coordinated varietal trial showed that BL3978 possessed the highest yield (2469.2 kg ha^{-1}) followed by NL1097 (2373.2 kg ha^{-1}) and NL1094 (2334.06 kg ha^{-1}). Genotype x environment interaction for grain yield was significant ($p<0.05$) over locations and years. BL3978 with early maturity (111 days) escaped the heat stress environment. Among the top three genotypes, BL3978 was consistently higher in both favorable and unfavorable conditions. Earliness was one of the major traits for heat tolerant genotypes. These lines also appeared suitable for inclusion in crossing program targeted for water stress tolerance.

Keywords: Alpha lattice, rainfed, water stress tolerance, wheat

1. Introduction

To keep pace with global population growth and food consumption patterns, future global food security will require agricultural production in 2050 to be 60 percent more than it was in 2010 (Alexandratos and Bruinsma, 2012). One promising pathway for increasing grain production is by bridging the gap between yields currently achieved on farms and those that can be achieved by using the best adapted crop cultivars and production practices (van Ittersum et al., 2013).

Environmental stresses affect gene expression and cellular metabolism (Lawlor, 2002). Major strategy of plants under stress conditions is decreasing the harmful effects caused by stresses (Sankar et al., 2007). Water stress affects complex of physiological/biochemical pathways which are engaged in metabolism of proteins, carbohydrates, lipids, hormones, effective minerals, free radicals and nucleic acids and also is related with the many stresses like salinity stress and cold stress (Flexas et al., 2007).

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Globally, about 37 percent of wheat growing areas are semi-arid in which available limited soil moisture constitutes a major problem in wheat production. Rainfed conditions provide the selection environment for drought tolerance. Around 22 percent of wheat area in the terai falls under rainfed and partially irrigated conditions (ABPSD, 2013). Bhrikuti, Aditya, NL971 and Vijaya released in 1994, 2009, 2009 and 2010, respectively are the options for rainfed condtions (NWRP, 2013). This reflects that the choices are limited. This research was conducted with an objective to develop superior wheat genotypes under rainfed environment of warm humid environment of Nepal.

2. Material and Methods

The experiments were conducted at Regional Agricultural Research Station (RARS), Nepalgunj and National Wheat Research Program (NWRP), Bhairahawa as coordinated varietal trial for the terai, tars and lower valleys under rainfed conditions. The materials consisted of eight spring wheat lines. Pedigree details of these lines are given in table 1. The wheat lines were evaluated for two consecutive crop seasons on normal sowing, i.e. December 4, using alpha lattice design with two replications. Rainfed plots received no water other than rainfall. The plot size was 10 rows of 4 m long at 25 cm spacing. Fertilizer and irrigation were applied as per recommendations.

Table 1: Genotypes used in the study 2011-12 and 2012-13

Genotypes	Cross
NL1140	WAXWING*2/VIVITSI
BL3978	NL729/BL2015
NL1094	KAUZ//ALTER84/AOS/3/PASTOR/4/TILHI
NL1143	WHEAR/VIVITSI/3/C80.1/3*BATAVIA//2*WBLL1
NL1093	WBLL1*2/TUKURU
NL1097	REH/HARE//2*BCN/3/CROC-1/AE.SQU(213)
Bhrikuti	BOW"S"/GH"S"
NL1135	PF74354//LD/ALD/4/2*BR12*2/3/

Temperature and rainfall information of NWRP, Bhairahawa and NWRP, Nepalgunj during the crop period, are mentioned below in figures 1 and 2, respectively.

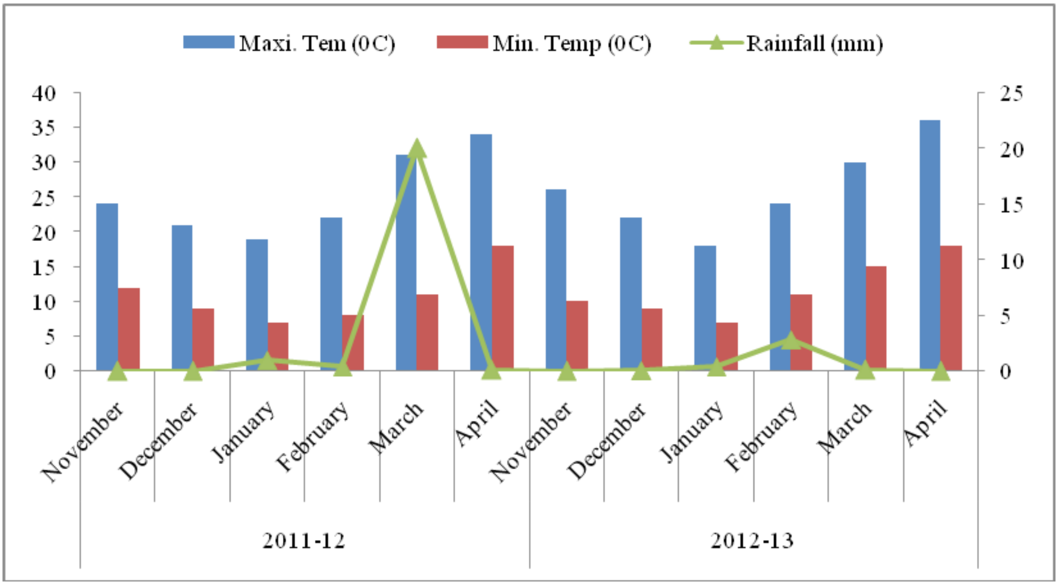

Figure 1. Meteorological information of Bhairahawa (2011-13)

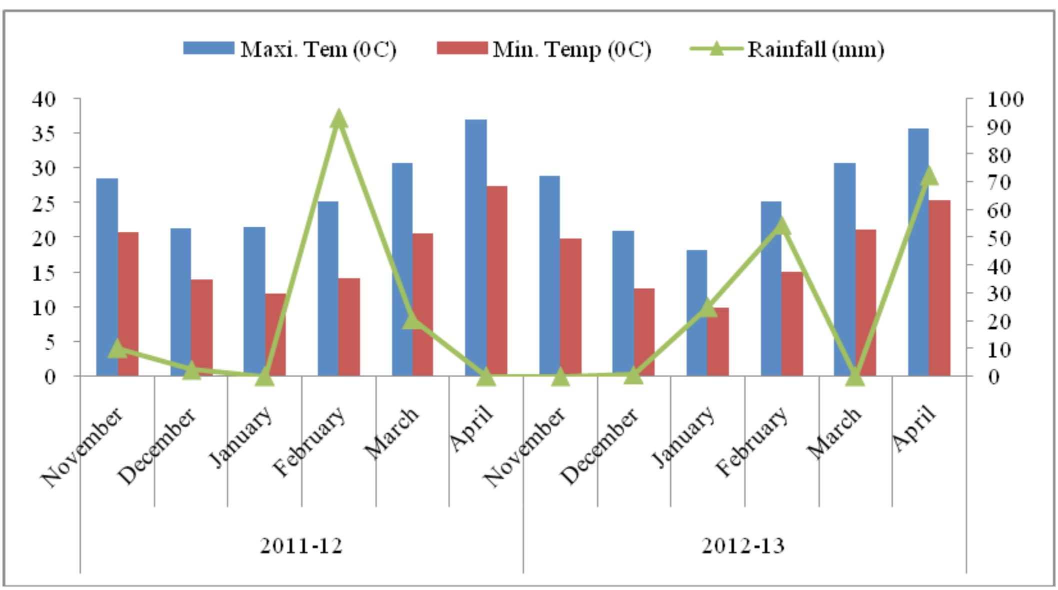

Figure 2. Meteorological information of Nepalgunj (2011-2013)

3. Results and Discussion

The combined analysis of coordinated varietal trial (CVT) showed that BL3978 (2469.2 kg ha^{-1}) possessed the highest yield followed by NL1097 (2373.2 kg ha^{-1}) and NL1094 (2334.06 kg ha^{-1}). Similarly, Genotype x environment interaction was found significant ($p<0.05$) to grain yield over locations over years (Table 2). The crop duration of BL3978 was lowest (DM=111) and was able to escape the heat stress environment. It can be concluded that the grain filling duration was low for BL3978. Early grain filling duration was reflected from the days to heading and its maturity, which was shorter than other tested varieties. Similarly, the rainfall was minimal in both the testing sites responding the significant difference in yield (environment x location) (Table 2).

Table 2: Phenological observations of wheat genotypes under rainfed conditions, 2011/12-2012/13

Genotypes	Day to heading	Days to maturity	Plant height (m)	Spikes/m^2	Grain yield (kg ha^{-1})
BL3978	78	111	89	209.84	2469.22
Bhrikuti	84	114	81.78	215.37	2417.34
NL1097	88	117	84.12	196.43	2373.28
NL1094	87.5	114	78.46	213.37	2334.06
NL1140	83.33	114	80.11	264.01	2305.05
NL1135	88.75	119	81.84	201.43	2278.44
NL1093	87.25	116	87.37	209.46	2052.34
NL1143	85.25	115	85.40	216.03	1918.28
Grand Mean	85.4	115	83.514	215.74	2268.50
CV (%)	2.67	1.96	7.09	16.74	13.08
LSD (5%)	4.56	4.52	11.84	72.25	593.63
EMS	5.1	5.112	35.06	1305	8.81E+04
Year	HS	HS	HS	HS	S
Environment x location	NS	NS	NS	NS	S
Environment	HS	HS	S	S	HS
Location	HS	HS	NS	NS	NS

HS: Highly Significant ($p<0.01$), S: Significant ($p<0.05$), NS: Non significant

There was significant variation among the tested genotypes with respect to grain yield (Table 2). The regression coefficient (b=0.82) of BL3978 was more than the regression coefficient (b=0.72) of Bhrikuti but near to 1. Similarly, the mean grain yield of BL3978 (2469±56.4 kg ha^{-1}) was higher than Bhrikuti (2417.3±52.5 kg ha^{-1}). It means BL3978 was more adaptive and higher yielding than Bhrikuti both under favorable and unfavorable regimes. Meanwhile, nearly equal mean yield fluctuation of both the varieties shows that BL3978 can perform same level of resistance to environmental changes as Bhrikuti.

Table 3: Stability parameters of wheat genotypes after regression of varietal mean on trial mean grain yield

Genotypes	N§	Grain yield (kg ha^{-1})		R^2 (%)	b	SE of b	t-value
		Mean ± SEM	Range				
BL3978	8	2469±56.4	2181-2800	93.9	0.82**	0.079	10.4
NL1094	8	2334±81.2	1980-2750	90.9	0.96**	0.11	8.4
Bhrikuti	8	2417.3±52.5	2100-2687	93.09	0.72**	0.07	9.7
NL1097	8	2385.7±158.3	1743-2937	86.1	1.48**	0.22	6.6

§Indicates numbers of trial for individual genotype; * and **, significant at 0.05 and 0.01 level of significance, respectively.

BL3978 could be a higher yielding, suitable and adaptive genotype as of Bhrikuti for rainfed conditions of Nepal. The grain yield of four varieties plotted against mean site yield also showed that BL3978 was consistently higher under both favorable and unfavorable growing environments (Fig.1). It means that BL3978 can perform consistently better yield than Bhrikuti in a good as well as poor environment. In addition, the leaf rust severity of 20S and foliar blight 77 confirms it is a good variety for the heat tolerant variety.

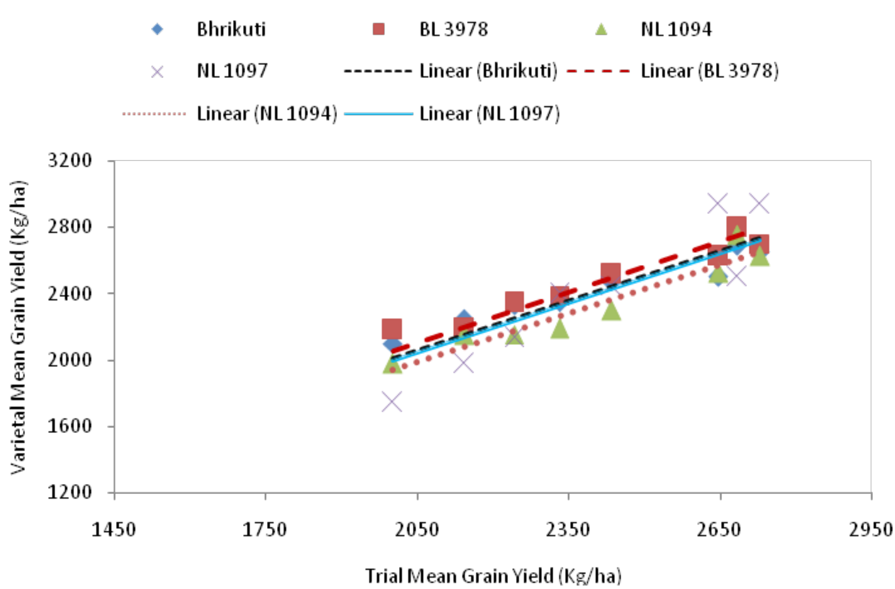

Figure 3. Stability (joint regression analysis) of four wheat genotypes across locations from coordinated varietal trial (CVT) yield data over two years, 2011/12-2012/13

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Performance of Botanicals and Impact of Pheromone Traps for Managing Fruit Fly (*Bactrocera cucurbitae*) in Summer Squash

Resona Simkhada

Abstract

Fruit fly, Bactrocera cucurbitae (Tephritidae, Diptera), is one of the notorious polyphagous pests of commercial cucurbit crops in Nepal and South East Asian countries. Field experiments were conducted using botanical pesticides and pheromones for the management of fruit fly in 2013 and 2014. All the treatments showed significant results and curtail the percent damage in comparison with untreated control. The marketable fruits were 85.3 percent in 2013 and 78.8 percent in 2014 in locally prepared botanical pesticide 'Jholmal'-treated plots. This treatment not only reduced the fruit fly infestation but also gave better yield (14 fruits/plant) and reduced protection costs. The peak trap catches were in vinegar and sugar- treated trap in the month of June for both the years (119 and 111 adults in 2013 and 2014, respectively). B. cucurbitae was positively correlated with temperature and negatively correlated with relative humidity. Total fruit fly per trap was higher (506±12.08 in 2013 and 512±11.05 in 2014) in cue-lure and malathion-treated trap.

Keywords: *Bactrocera cucurbitae,* botanical pesticides, summer squash, temperature

1. Introduction

Tephritid fruit flies are amongst the persistent pest species of fruits and vegetables in the world causing direct and indirect economic fatalities due to their injury (Sarwar, 2006). The genus *Bactrocera* is considered a notorious pest, a serious threat of horticultural crops because of the wide host range of its species and the invasive power of some species within the genus (Clarke et al., 2005). Its geographical distribution covers most countries in South East Asia. Fruit fly (*Bactrocera cucurbitae*) causes serious pre and post-harvest losses. There are evidences where losses have been up to 100percent in cucurbit species, due to *B. cucurbitae* (Dhillon et al., 2005). They are widespread, and feed on hundreds of host plant species, many of which are economic crops. The larvae feed on the pulp of host fruits, riddling and polluting the pulp, and eventually reducing the whole to an inedible mass.

The fruit fly has been reported to damage 81 host plants and is a major pest of cucurbitaceous vegetables; particularly the bitter gourd (*Momordica charantia*), muskmelon (*Cucumis melo*), snap melon

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(*C. melo* var. *momordica*), and snake gourd (*Trichosanthes anguina*) (Dhillon et al., 2005). One of the primary cucurbit crops attacked by fruit fly in Nepal is summer squash (*Cucurbita pepo*). A major constraint for its improved production is high rate of fruit fly infestation. Due to the larva's three instars the fruits can be totally destroyed (Ye and Liu, 2005). Because of the fruit fly's wide host range its effect on agriculture is far-reaching and warrants systematic research. Implementation of bio-pesticides in agro-ecosystem cannot be isolated due to the fact that indiscriminate pesticides use leads to the extinction of natural enemies of fruit flies and the development of resistance of these and other pests (Banjo et al., 2010). Unlike insecticide cover sprays, the protein baits, lures and botanicals are environmentally friendly and do not affect non-target organisms, including consumers. The present study attempts to determine the efficacy of lures, and application of biopesticide for managing *B. cucurbiate* on summer squash under field conditions.

2. Materials and Methods

The experiment was conducted during February to July 2013 and 2014 in Agriculture Research Station (ARS, Horticulture), Pokhara, Kaski located at $28^0$13'6.8" N latitude and $83^0$58'27.72" E longitude at a mean elevation of 848 meter above sea level. This region is characterized by sub tropical weather with an annual average maximum temperature of 32^0C and minimum of 8^0C. The experiments were laid out in a randomized complete block design (RCBD) with four replications. Thirty-day-old healthy seedlings of summer squash were transplanted on 23rd January in both the years at the geometry of 90 cm x 90 cm. Fertilizers were applied @ 120:80:60 NPK kg ha^{-1} and FYM @ 40 t ha^{-1}.

The treatments included (1) 5 drops of cue-lure [4-(p-acetoxyphenyl)-2-butanone] with 0.5 ml malathion applied to a cotton wick, replenished at 15 days interval, (2) 0.25 ml vinegar and sugar- treated cotton wick with soap water, soapy water replaced at a week interval, (3) 0.4 ml cue-lure with 1 ml dichlorvos (Nuvan) applied to a cotton wick, replaced at 15 days interval, (4) a locally prepared bio-pesticide 'Jholmal', and (5) untreated control. The Jholmal was prepared using 2 kg leaf, stems and florets of each neem (*Azadirachta indica*), titepati (*Artemisia vulgaris*), tulsi (*Ocimum sanctum*), bojho (*Ocorus calamus*), tejpat (*Cinnamomum tamala*), and sisnu (*Urtica dioca*) with twenty liter cow urine, fermented for a month in a container, and sprayed weekly with dilution of 1:6 ratio. In the field, the traps were hung from stalks close to the field and about 1 m above the ground; number of fruit flies per trap was recorded. Five plants in the middle of the experimental unit (20 interior plants, i.e. 5 plants per treatment per replication) were considered for recording observations. The observations were recorded on total number of fruits produced, harvested damage (numbers and weight), and fruit yield. The percentage of fruit infestation was calculated using the formula:

Percentage of infested fruits = Number of infested fruits/Number of total fruits × 100

Data on temperature, relative humidity and rainfall of the study site were obtained from meteorological unit of ARS (Horticulture), Kaski.

The data were subjected to analysis of

variance (ANOVA) using GENSTAT® Discovery Edition 4 statistical package. The treatment means were evaluated using least significant differences (LSD) test at P=0.05 probability level.

3. Results and Discussion

3.1 Effect of Lures and Jholmal on Production of Marketable and Unmarketable Summer Squash

In 2013, the effects of the treatments were highly significant (P<0.001) for the marketable number, marketable weight and total fruit number of summer squash (Table 1). The locally prepared botanical pesticide 'Jholmal' was found the most effective. Of the total fruits harvested both the marketable number (85.3%) and weight (92.4%) were higher in Jholmal-treated plots followed by cue-lure and malathion (64.1%), and vinegar and sugar (64%). Significant number of fruits was damaged (61.8%) in untreated control plot.

Table 1: Effect of different traps and botanical pesticide on production of marketable and unmarketable fruits of summer squash, Malepatan, Kaski, 2013 (unmarketable fruits refers to damaged fruits due to *Bactrocera cucurbitae*)

Treatments	Marketable number (%)	Unmarketable number (%)	Marketable weight (%)	Unmarketable weight (%)	Number of total fruits
Cue-lure with malathion	64.1	35.9	77.4	22.6	12.50
Cue-lure with dichlorvos	56.6	43.4	68.1	31.9	11
Vinegar and sugar with soap water	64.0	36.0	77.2	22.8	12.50
Jholmal*	85.3	14.7	92.4	7.6	13.75
Untreated control	38.2	61.8	49.5	50.5	10.50
Grand mean	61.6	38.4	72.9	27.1	11.80
P-Value	<0.001	<0.001	<0.001	<0.001	<0.001
LSD	7.56	7.56	9.37	9.37	1.125
CV %	8	12.8	8.3	22.4	6.1

*Locally prepared botanical pesticide

Like in 2013 the effects of treatments in 2014 were highly significant (P<0.001) for the marketable number and marketable weight of summer squash, and significant (P<0.05) for total fruit number (Table 2). The "Jholmal" gave highest number of healthy marketable fruits (78.8%) followed by the effect of cue-lure and malathion (67.7%), and vinegar and sugar (63.1%). The untreated control plots had the highest number of unmarketable fruits (55.7%).

Larval damage may serve as avenues for the advancement of secondary harmful organisms and causes fruit demolition. Furthermore, the occurrence of *B. cucurbitae* at high population densities in the field is allied with the utmost level of damage observed, escorting to high economic losses in squash production with severe impacts on agriculture and environment. Botanicals used in 'Jholmal' may have numerous active ingredients of insecticidal properties as Singh and Sehgal (2001) reported that plants contain thousands of compounds which are virtually an untapped reservoir of pesticides that can be used directly or as templates for synthetic pesticides.

Table 2: Effect of different traps and botanical pesticide on production of marketable and unmarketable fruits of summer squash, Malepatan, Kaski, 2014 (unmarketable fruits refers to damaged fruits due to *Bactrocera cucurbitae*)

Treatments	Marketable number (%)	Unmarketable number (%)	Marketable weight (%)	Unmarketable weight (%)	Number of total fruits
Cue-lure with malathion	67.7	32.3	83.85	16.15	11.50
Cue-lure with dichlorvos	59.1	40.9	66.79	33.21	11.00
Vinegar and sugar with soap water	63.1	36.9	79.38	20.62	11.75
Jholmal*	78.8	21.2	91.18	8.82	13
Untreated control	44.3	55.7	53.48	46.52	9.75
Grand mean	62.6	37.4	79.94	25.06	11.50
P-Value	<0.001	<0.001	<0.001	<0.001	0.05
LSD	6.96	6.96	4.73	4.73	1.44
CV %	7.2	12.1	4.1	12.3	8.2

*Locally prepared botanical pesticide

3.2 Comparison of Different Attractants Used in Traps

The results showed cue-lure with malathion as the most effective attractant followed by vinegar and sugar with soap water (Table 3). Cue-lure with dichlorvos was least effective. That could be due to strong odor of dichlorvos and its repellent actions against fruit flies.

Table 3: Adult of *Bactrocera cucurbitae* captures in different trap composition placed in cucurbit field during February to August 2013 and 2014 in Pokhara, Kaski

Trap/Attractant	Killing agent	Relative trap efficiency - total fruit fly/trap (±SE)	
		Year I	Year II
Cue-lure	Malathion	506±12.08	512±11.05
Vinegar and sugar	Soap water	486±12.29	432±11.16
Cue-lure	Dichlorvos	293±7.50	270±6.91

3.3 Population Fluctuation

Figure 1 showed the population fluctuation of fruit fly adults during the field test as shown by number of fruit flies captured in the traps baited with different attractants and killing agents. The trend of population fluctuation remained almost same for both the years with the peak in the month of June.

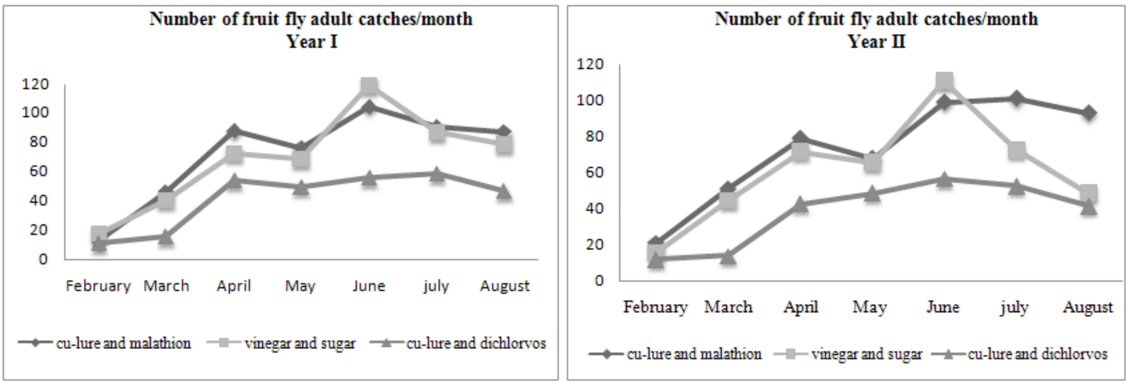

Figure 1. Number of total fruit flies captured per trap per month, in year 1 (2013) and year 2 (2014)

Correlation between fruit fly populations and temperature was highly significant (P<0.01), and it was significant between fruit fly and rainfall for both the years (Table 4). The occurrence of *B. cucurbitae* was negatively correlated with relative humidity. The dominance of fruit fly coincided with the fruiting season of summer squash, i.e. the months of June and July having higher temperature and rainfall. These findings are in agreement with Bateman (1977) who reported that temperature is a key factor in regulating the development rates and other population processes in fruit flies. Christenson and Foote (1960) also reported that rainfall is another factor that police fruit fly activity beside temperature.

Table 4: Pearson's correlation coefficient between the occurrence of fruit flies and weather parameters at ARS (Horticulture), Kaski, 2013 (Year 1) and 2014 (year 2)

Number of fruit fly	Average temperature	Rainfall	Humidity
Year 1	0.925**	0.533	-0.028
Year 2	0.949**	0.59	-0.066

Figures with asterisks are highly significant (P<0.01)

4. Conclusion

The polyphagous fruit fly, *B. cucurbitae,* population can be managed using a locally prepared botanical pesticide 'Jholmal'. An eco-friendly trap using vinegar and sugar with soap water was effective in managing fruit flies. The results suggest that vinegar and sugar mixture could also be considered as an efficient attractant.

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Soil Properties and Nutrient Uptake by Wheat (*Triticum aestivum* L.) as Influenced by Tillage, Residue and Nitrogen

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Abstract

A field experiment was conducted at farmer's field at Aanandavan-5, Manigram, Rupandehi, Nepal during winter season of 2010 and 2011 to study the soil properties and nutrient uptake by wheat as influenced by tillage, residue and nitrogen. The experiment was laid out in a split-split-plot design with three replications. There were twelve treatment combinations consisting of two levels of tillage (zero tillage and conventional tillage) in main plot, two levels of residue (without residue except root biomass and retention of rice residue at 25 cm height) in sub-plot and three levels of nitrogen (0, 100 and 150 kg ha^{-1}) in sub-sub-plot. Zero tillage showed slightly higher soil organic matter, nitrogen, and phosphorus contents but lower soil pH and potassium contents than conventional tillage. Residue application produced higher soil organic matter, pH, nitrogen, phosphorus and potassium than no residue application. Application of 150 kg N ha^{-1} gave lower soil organic matter, pH, phosphorus and potassium contents but higher soil nitrogen content (0.072%) than other levels of nitrogen application. Total uptake of major nutrients by wheat was not significantly affected by tillage and residue but application of 150 kg N ha^{-1} showed significantly higher uptake of nitrogen (64.875 kg ha^{-1}), phosphorus (28.546 kg ha^{-1}) and potassium (27.438 kg ha^{-1}) than other levels of nitrogen application; however, zero tillage showed higher uptake of nitrogen (53.919 kg ha^{-1}), phosphorus (23.351 kg ha^{-1}) and potassium (22.561 kg ha^{-1}) than conventional tillage; and residue application showed higher uptake of nitrogen (51.166 kg ha^{-1}) and potassium (22.115 kg ha^{-1}) but lower uptake of phosphorus (22.588 kg ha^{-1}) than residue removal.

Keywords: Nitrogen, nutrient uptake, residue, residual properties, tillage, wheat

1. Introduction

Wheat (*Triticum aestivum* L.) is the most important cereal crop of the world providing staple food for 35 percent of world's population. Wheat ranks first both in the acreage and production of the world (UNDP and FAO, 2002). It ranks third important cereal crop (after rice and maize) in Nepal with production, productivity and area 17,46,000 ton, 2.28 ton per ha and 7,67,000 ha, respectively. Wheat contributes 7.14percent of AGDP of the country (MoAC, 2011). To provide food for rapidly growing population,

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Nepal needs to increase the production of wheat by 0.6 ton per ha by the end of 2020 (Gami et al., 2001). The major reasons for low productivity of wheat are delay in sowing, decline of soil organic carbon and deteriorate soil physical structure depleted soil fertility, imbalanced use of nutrition, low nutrient use efficiencies, weed problem, labor scarcity, high cost of inputs and other problems of local nature (Tripathi et al., 2003b).

Delayed planting after mid-December causes 30-50 kg/day/ha, i.e. 1-1.5percent yield reduction per day (Sayre, 2000) which could not be reversed with better crop management and application of inputs. Excess moisture in the field just after rice harvesting makes land preparation difficult that delay the sowing. Persistent use of conventional farming practices based on extensive tillage have magnified soil erosion losses and the soil resource base has been steadily degraded, especially when tillage is combined with in-situ burning of crop residues (Montgomery, 2007). Wheat cultivation in no-till soil of a post rice harvest field utilizes residual soil moisture and reduces the time period from rice harvest to wheat seeding in intensive-rice wheat cropping system.

Crop residue recycling is one of possible remedial measure to improve total factor productivity (Chatrath et al., 2007). Application of rice straw leads to immobilization of nitrogen (Janssen, 1996) but the faster decomposition and release of N to soil is possible if it is treated with urea and applied during field preparation (Sharma and Bali, 1998). Crop residues provide substrate for microorganisms and have potential to increase soil organic matter.

Besides late planting, nutrient mining and emergence of multiple nutrient deficiencies are other responsible factors for declining wheat productivity (Tripathi et al., 2003a). Among them, nitrogen plays an important role in wheat production. Stagnation and even decline in yields in the rice-wheat systems has been shown by some long-term experiments in South Asia (Regmi et al., 2002) and dominating both long term and short term problems are soil fertility issues, primary associated with nitrogen deficiency in wheat. Singh et al. (2003) reported dry matter accumulation, leaf area index, crop growth rate and assimilation rate, measured at different stages increased significantly with balanced N fertilizer application. The present study was conducted with the objectives to assess the soil physicochemical properties and nutrients uptake under different tillage, residue and nitrogen levels.

2. **Materials and Methods**

The field experiment was conducted in a farmer's field at Aanandavan-5 in Rupandehi district of Nepal during 2010/11. The experiment was laid out in a split-split plot design with three replications. There were twelve treatment combinations consisting of two levels of tillage (zero tillage and conventional tillage) in main plot, two levels of residue (without residue except root biomass and retention of rice residue at 25 cm height) in sub-plot and three levels of nitrogen (0, 100 and 150 kg ha^{-1}) in sub-sub-plot. Each individual plot had 5 m length and 3.24 m width. The soil texture was silt loam (37.03% sand, 49.32% clay and 13.85% clay) with average soil nitrogen (0.072%), available phosphorus (62.96 kg ha^{-1}), exchangeable potassium (87.30 kg ha^{-1}), pH (6.94) and organic matter content (1.475%). Meteorological data shows cool winter (November to February) and hot spring (March to May) with appreciable amount of rainfall before sowing of wheat and during growth stage. The highest monthly average maximum temperature (36.43^{0}C) was faced by crop in April that coincided with the post flowering stage and the lowest monthly average minimum temperature (7.32^{0}C) was faced in January.

The test wheat variety was Bhrikuti. In conventional tillage, ploughing was done with tractor drawn cultivators. Rice straw was cut 0.25 m above ground level for straw application which was incorporated in conventional tillage and retained in zero tillage. Nitrogen was applied as per treatments in which half dose of nitrogen, whole doses of P_2O_5 (50 kg ha^{-1}) and K_2O (25 kg ha^{-1}) were applied at sowing. Rest one fourth of the nitrogen was applied at crown root initiation (CRI) stage just after irrigation and the rest ¼ at heading stage after second irrigation. Urea, single super phosphate and murate of potash were used as the source of nitrogen, phosphorus and potassium, respectively. Sowing was done with seed cum fertilizer drill on 21st November 2010. Weeding was done as and when necessary. Harvesting of 1 m^2 area was done manually on 10th April, 2011 and dried for three days to record yield data. Plant samples were collected randomly excluding border plants from each plot for plant analysis. Soil samples were collected diagonally from three spots of each plot at a depth of 0-15 cm using tube auger and composite sample was prepared which was air-dried, ground and sieved through 2 mm sieve for analysis. Soil samples were also taken for soil moisture determination at 30 days interval.

Soil samples were analyzed for texture, organic matter, N, P_2O_5 and K_2O and pH to determine initial and residual physicochemical properties of soil. Plant samples were analyzed for NPK concentration and nutrient uptake was calculated using following formula:

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%) x yield (kg ha}^{-1}\text{)}}{100}$$

Collected data were analyzed with ANOVA using MSTAT-C statistical computer package. The least significant difference (LSD) at 5percent probability was used to compare means of treatments.

3. Results and Discussion

3.1 Residual Soil Properties

3.1.1 Soil Nitrogen

Zero tillage produced slightly higher nitrogen content (0.069%) over conventional tillage (0.067%). Gangwar et al. (2004) also reported greater available soil N from zero tillage than conventional tillage. Application of residue increased soil nitrogen content by 15.873 percent. Higher soil N from straw retention could be due to addition of nitrogen from straw, slower decomposition and immobilization into microbial mass which reduced loss of nitrogen (Bacon, 1990). Application of higher level of nitrogen showed higher residual soil-N although it was not significant (Table 1).

Table 1: Effects of tillage, residue and nitrogen on residual soil properties at Manigram, Rupandehi, Nepal, 2010/2011

Treatments	Soil N (%)	Soil phosphorus (kg ha^{-1})	Soil potassium (kg ha^{-1})	Soil organic matter (%)	Soil pH
Tillage:					
Conventional	0.067	57.404	87.383	1.409	6.667
Zero	0.069	64.681	84.958	1.482	6.606
SEm	0.004	4.380	1.146	0.0395	0.0258
LSD	NS	NS	NS	NS	NS
Residue:					
With	0.073	61.172	88.467	1.461	6.656
Without	0.063	60.914	83.874	1.431	6.617
SEm	0.006	2.138	3.601	0.0543	0.0393
LSD	NS	NS	NS	NS	NS
Nitrogen:					
No nitrogen	0.066	63.746	86.546	1.493	6.683
100 kg/ha	0.067	60.410	86.541	1.429	6.625
150 kg/ha	0.072	58.973	85.425	1.415	6.600
SEm	0.005	3.652	3.773	0.0620	0.0696
LSD	NS	NS	NS	NS	NS
CV (%)	27.27	20.73	15.17	11.07	3.64

NS: not significant

3.1.2 Soil Available Phosphorus

The highest soil available phosphorus (64.681 kg ha^{-1}) was observed from zero tillage and the lowest (57.404 kg ha^{-1}) from conventional tillage (Table 1) even though it was not significant. Reduced tillage practices resulted in more soil P in surface layers than the sub-soil layers (Diaz-Zorita, 2000). Slightly higher soil available phosphorus (61.172 kg ha^{-1}) was observed from rice residue application and the lowest (60.914 kg ha^{-1}) from no residue application, which might be due to slow release of inorganic phosphorus during decomposition and reduced fixation (Mandal et al., 2004). Increasing levels of nitrogen reduced residual soil available phosphorus.

3.1.3 Soil Available Potassium

Soil exchangeable potassium was the highest (87.383 kg ha^{-1}) from conventional tillage and the lowest (84.958 kg ha^{-1}) from zero tillage although it was not significant (Table 1). Ibrahim (2009) also reported higher potassium content from conventional tillage and deep tillage than minimum tillage. Application of rice residue showed the highest soil exchangeable potassium (88.467 kg ha^{-1}) although it was not significant and it was the lowest (83.874 kg ha^{-1}) from no rice residue application. Increasing level of nitrogen reduced soil exchangeable potassium. Use of higher quantities of nitrogen encouraged better growth of crop, uptake of potassium and in turn there was heavy depletion of soil potassium.

3.1.4 Soil Organic Matter (SOM)

Effect of tillage and residue on soil organic matter was not significant but the highest soil organic matter (1.482%) was observed in from zero tillage and lowest (1.409%) from conventional tillage (Table 1). After study of 8 cropping seasons, Malhi and Lemke (2007) reported no significant effect of tillage on soil organic matter in 0-15 cm depth but light fraction of organic carbon was higher from zero tillage than conventional tillage. The highest SOM (1.461%) was resulted from application of residue and the lowest (1.431%) from no residue application. Increasing level of nitrogen reduced SOM. Hejazi et al. (2010) reported higher soil organic carbon (SOC) from application of residues and lower SOC with increasing nitrogen level.

3.1.5 Soil pH

Soil pH was the highest (6.667) from conventional tillage and residue application (6.656) and the lowest from zero tillage (6.606) and without residue (6.617). Ismail et al. (1994) observed a larger decrease in pH and extractable Ca and Mg in the top 5 cm as N rates increased in no-tilled compared to tilled soil. Rice crop residues are highly siliceous, and have the potential of transforming electrochemical properties of acidic soils improving base retention and increasing the soil pH (Mandal et al., 2004). Soil pH decreased with increasing rate of nitrogen (Table 1), which might be due to net release of H^+ ions during urea mineralization.

3.2 Nutrient Uptake

3.2.1 Nitrogen Uptake

Effect of tillage and residue on nitrogen uptake was not significant but zero tillage increased nitrogen uptake by 15.31 percent than conventional tillage (Table 2). Similar result was reported by Mishra et al. (2011). Application of residue showed slightly higher nitrogen uptake (51.166 kg ha^{-1}) than without residue (49.513 kg ha^{-1}). Significantly higher nitrogen uptake (64.875 kg ha^{-1}) was observed from application of 150 kg ha^{-1} than 100 kg ha (56.369 kg ha^{-1}) and no nitrogen (29.774 kg ha^{-1}). Increasing level of nitrogen increased nitrogen uptake.

Table 2: Effects of tillage, residue and nitrogen on nutrient uptake by wheat at Manigram, Rupandehi, Nepal, 2010/2011

Treatments	Nutrient uptake (kg ha^{-1})		
	Nitrogen	Phosphorus	Potassium
Tillage:			
Conventional	46.760	22.625	21.797
Zero	53.919	23.351	22.561
SEm	0.936	0.4360	0.446
LSD	NS	NS	NS
Residue:			
With	51.166	22.588	22.243
Without	49.513	23.388	22.115
SEm	2.700	0.8652	0.222
LSD	NS	NS	NS
Nitrogen:			
No nitrogen	29.774^{c}	14.321^{b}	14.173^{c}
100 kg ha^{-1}	56.369^{b}	26.097^{a}	24.926^{b}
150 kg ha^{-1}	64.875^{a}	28.546^{a}	27.438^{a}
SEm	2.444	0.8652	0.571
LSD	6.731**	2.930**	1.713**
CV (%)	16.85	14.43	8.92

NS: not significant

3.2.2 Phosphorus Uptake

Phosphorus uptake varied insignificantly from tillage and residue but application of nitrogen significantly increased phosphorus uptake. Application of 150 kg N ha^{-1} showed significantly higher phosphorus uptake (28.546 kg ha^{-1}) than no nitrogen application which was at par with 100 kg ha^{-1} (26.097 kg ha^{-1}). Significantly higher phosphorus uptake was observed from 100 kg N ha^{-1} than no nitrogen application (Table 2). Proper management of nitrogen promotes phosphorus uptake by plants increasing top and root growth, altering plant metabolism and increasing the solubility and availability of P (Havlin et al., 2003).

3.2.3 Potassium Uptake

Potassium uptake was slightly higher from zero tillage (22.561 kg ha^{-1}) and residue application (22.243 kg ha^{-1}) than conventional tillage (21.797 kg ha^{-1}) and without residue (22.115 kg ha^{-1}). Bauer et al. (2002) reported better utilization of soil moisture, water use efficiency and higher nutrient uptake from zero tillage. Application of 150 kg N ha^{-1} showed significantly higher potassium uptake (27.438 kg ha^{-1}) than 100 kg N ha^{-1} (24.926 kg ha^{-1}) and no nitrogen application (14.173 kg ha^{-1}). Application of 100 kg N ha^{-1} showed significantly higher uptake of potassium than no nitrogen application (Table 2). This result was in accordance with the findings of Tandon and Sekhon (1988) that large quantities of nitrogen used in intensive rice-wheat cropping system encouraged crop uptake of nitrogen and potassium.

The potassium uptake from the application of 100 or 150 kg N ha^{-1} was statistically similar when residue was applied (Table 3). However, both of them significantly increased the potassium uptake as compared to no nitrogen (12.938 kg ha^{-1}). On the other hand, application of 150 kg N ha^{-1} increased the potassium uptake (27.361 kg ha^{-1}) significantly than application of 100 kg N/ha (23.576 kg ha^{-1}) which was also significantly higher than no nitrogen (15.408 kg ha^{-1}) when no residue was applied.

Table 3: Interaction effects of residue and nitrogen on potassium uptake by wheat at Manigram, Rupandehi, Nepal, 2010/2011

Treatments	Potassium uptake (kg K ha^{-1})		
	Nitrogen levels		
	No nitrogen	100 kg N ha^{-1}	150 kg N ha^{-1}
With residue	12.938^{d}	26.275^{a}	27.515^{a}
Without residue	15.408^{c}	23.576^{b}	27.361^{a}
LSD	2.422		
CV (%)	8.92		

There was significant influence of residue application on potassium uptake when no and 100 kg N ha^{-1} was applied, where residue application significantly increased the potassium uptake. However, no such influence of residue application was observed when 150 kg N ha^{-1} was applied.

4. Conclusion

Tillage and residue application do not affect nutrient uptake. Increasing level of nitrogen enhanced the uptake of major nutrients (NPK). Application of residue should be accompanied with nitrogen fertilization to increase potassium uptake.

Zero tillage and residue application showed improvement in residual soil fertility and increased soil organic matter which might benefit next crop and sustain soil resource base. Therefore, zero tillage and residue application can be suggested for wheat cultivation where farmers generally remove residue and adopt conventional tillage.

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Screening Nepalese Wheat (*Triticum aestivum* L.) Genotypes through Variability and Correlation Study of Drought Adaptive Morpho-physiological Traits

D. Pokharel[1], R. Simkhada[2], and M. P. Pandey[3]

Abstract

Wheat (Triticum aestivum L.) is the most important cereal crop for global food supply. Most of the wheat crop in developing countries including Nepal is either grown under rainfed conditions or under limited irrigation conditions, thus water stress hits the wheat crop at different growth stages which thus limiting the grain yield. An experiment was carried out at the Institute of Agriculture and Animal Science, Rampur to screen 60 different wheat genotypes selected on drought adaptive morpho-physiological traits. The wheat genotypes comprised of Nepalese landraces and commercial cultivars, CIMMYT-derived advanced introduction lines and three checks with differential drought adaptability. The selected wheat genotypes y were grown in pots (single plant) arranged in a replicated split plot design in greenhouse under two contrasting moisture regimes i.e. optimum and moisture stressed. They were evaluated for water use, water use efficiency (WUE), relative leaf water content, number of tillers, plant height, flag leaf area, phenological periods and biomass production. The results showed significant variations between environments and among the wheat germplasms for most of the drought adaptive traits. A wide range of variability was observed for the selected drought adaptive morpho-physiological traits in moisture stressed and non-stressed environments. WUE was significantly correlated with biomass production. Nepalese cultivar Gautam showed a number of favorable drought adaptive traits. A number of landraces and advanced breeding lines showed high level of water use efficiency and other positive traits for drought adaptation.

Keywords: Biomass production, booting, correlation, flag leaf area, plant height, relative water content, water stress, water use efficiency

1. Introduction

Wheat (*Triticum aestivum* L.) is the most important cereal crop of the world providing staple food for 35 percent of the world population (FAOSTAT, 2011). It is the major staple crop in the Eastern Gangetic Plains (EGP) of South Asia, a region comprising the plains of eastern India, southern Nepal, Bangladesh and Pakistan. This region is regarded as a low-income region with a vast number of small and marginalized farmers. The acreage

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under wheat cultivation in this region is over 36 million hectares, which is around 16 percent of the global wheat area and produces 15percent of the global wheat (CIMMYT, 2009). Wheat ranks third important crop in Nepal, which is grown in 767499 ha land with the productivity of 2275 kg ha^{-1}. It contributes 7.14 percent to agricultural gross domestic products (MOAC, 2011).

Water is becoming scarce for wheat crop in south Asia as less water recharge from rainfall (Singh, 2000). Moisture stress is one of the major abiotic factors limiting wheat production worldwide (Richards et al., 2002). In a survey that covered 102 million ha of wheat area in the developing countries (47% global wheat area or 89% of the wheat area in developing countries) revealed moisture stress as one of the major constraints to wheat production with and estimated annual yield loss of 19 to 50 percent (Kosina et al., 2007).

Drought stress has been recognized as one of the major abiotic factors limiting wheat production in India (Joshi et al., 2007), Pakistan (Kisana et al., 2008) and Nepal (Bhatta et al., 2008). In Nepal, winter drought had a major constraints on yields on wheat and other winter crops and assumed to increases as a changing climate with increase of hotter and drier days, lower water table (WFP, 2009). As a result, crop growth rate is reduced and yield is lowered. Despite these risks, there is a large untapped yield potential that needs to be explored by screening drought tolerant crop germplasms of different crops in rainfed agriculture.

Nepal being the hot spot of biodiversity (Shrestha and Shrestha, 1999) encompasses the existence of 405 local landraces of wheat from mid-western and far-western districts of Jumla and Humla, respectively. Genetic resources provide an invaluable gene pool for crop breeding (Reynolds et al., 2007). The majority of wheat landraces in Nepal have not been characterized for drought tolerance and their potential to improve drought adaptation is not quantified.

Information regarding association of these morpho- physiological characteristics to biological yield is of paramount importance in crop breeding programs. It is done to ascertain the expected response of these traits to the overall outcome by measurement of coefficient of correlation (Dabholkar, 1992). Khaliq et al. (2008) reported positive association of flag leaf area and grain yield in bread wheat. Correspondingly, specific flag leaf area also exhibited strong positive relationship with yield, while negative association with specific leaf weight. Relative water content was found positively associated with the relative dry weight (Clarke et al.,1991). Sharma et al. (1995) reported that grain yield per plant in wheat was significantly and positively correlated with plant height, ear length, tillers per plant, biological yield and ears per plant. Biological yield in wheat showed positive and significant correlation with grain yield, tillers per plant, test weight and flag leaf area, while negative association with days to heading and harvest index (Munir et al., 2007). Subhani and Chowdhry (2000) found a positive relationship of grain yield with flag leaf area, plant height, spike length, grains per spike, test weight, biomass per plant and harvest index, while days to booting shows negative correlation with grain yield.

Due to lack of high throughput screening techniques and high cost factors in developing countries like Nepal, indirect selection was performed. Researchers (Omae et al., 2007, Singh et al., 2007, and Sharma et al., 2007) are also of the opinion that better adapted and high yielding genotypes could identified by screening morpho-physiological traits in the early phase of breeding programs. Hence, in this research we tried to elucidate the superior wheat germplasm for drought adaptation through study of genetic variability of drought adaptive morpho-physiological traits and their association to biological yield for improving the drought adaptation of 60 different wheat genotypes of wheat including Nepalese landraces, commercial cultivars, advanced lines and some international cultivars under two water regimes; moisture stressed and optimum stress.

2. Materials and Methods

This study was conducted in a greenhouse of Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan, Nepal in 2009. Sixty wheat genotypes were included in the study. They include 24 Nepalese wheat landraces obtained from Agricultural Botany Division, Khumaltar, Lalitpur; 30 advanced breeding lines from the National Wheat Research Program, NARC, Bhairahawa; three international check cultivars namely, Dharwar Dry (drought tolerant), Hartog (standard high yielding cultivar) and SeriM82 (a high yielding cultivar recommended for water limiting areas). Dharwar Dry is an Indian landrace selected by CIMMYT for dry areas, whereas, Hartog and SeriM82 are Australian cultivars. In addition, three Nepalese commercial cultivars - Gautam, Bhrikuti and Vijaya were also included in the study. The details of the wheat germplasms used in this study are given in table 1.

Table 1: Wheat genotypes and their source

Germplasm	Type	Source	Germplasm	Type	Source
NPGR 5610	Landrace	ABD	ABL7	Adv. Line	NWRP
NPGR 5988	Landrace	ABD	ABL8	Adv. Line	NWRP
NPGR 6001	Landrace	ABD	ABL9	Adv. Line	NWRP
NPGR 6573	Landrace	ABD	ABL10	Adv. Line	NWRP
NPGR 6612	Landrace	ABD	ABL11	Adv. Line	NWRP
NPGR 6696	Landrace	ABD	ABL12	Adv. Line	NWRP
NPGR 7439	Landrace	ABD	ABL13	Adv. Line	NWRP
NPGR 7487	Landrace	ABD	ABL14	Adv. Line	NWRP

NPGR 7504	Landrace	ABD	ABL15	Adv. Line	NWRP
NPGR 7782	Landrace	ABD	ABL16	Adv. Line	NWRP
NPGR 7789	Landrace	ABD	ABL17	Adv. Line	NWRP
NPGR 8228	Landrace	ABD	BL 3827	Adv. Line	NWRP
NPGR 8232	Landrace	ABD	BL 3845	Adv. Line	NWRP
NPGR 8233	Landrace	ABD	BL 3798	Adv. Line	NWRP
NPGR 8748	Landrace	ABD	BL 3787	Adv. Line	NWRP
NPGR 8749	Landrace	ABD	BL3555	Adv. Line	NWRP
NPGR 8752	Landrace	ABD	BL 3899	Adv. Line	NWRP
NPGR 8753	Landrace	ABD	BL 2800	Adv. Line	NWRP
NPGR 8762	Landrace	ABD	BL 3924	Adv. Line	NWRP
NPGR 8903	Landrace	ABD	BL 3940	Adv. Line	NWRP
NPGR 8904	Landrace	ABD	BL3561	Adv. Line	NWRP
NPGR 8911	Landrace	ABD	NL 1042	Adv. Line	NWRP
NPGR 9447	Landrace	ABD	BL 3625	Adv. Line	NWRP
NPGR 10548	Landrace	ABD	BL 3791	Adv. Line	NWRP
ABL1	Adv. Line	NWRP	Dharwar dry	Landrace	QDPIF/India
ABL2	Adv. Line	NWRP	SeriM82	Adv. Line	QDPIF/ CIMMYT
ABL3	Adv. Line	NWRP	Hartog	Cultivar	QDPIF/ Australia
ABL4	Adv. Line	NWRP	Bhrikuti	Cultivar	NWRP
ABL5	Adv. Line	NWRP	Gautam	Cultivar	NWRP
ABL6	Adv. Line	NWRP	Vijaya	Cultivar	NWRP

Note: Adv. lines=Advanced breeding lines. ABD=Agriculture Botany Division, Nepal, NWRP=National Wheat Research Program, Nepal, QDPIF=Queensland Department of Primary Industries and Fisheries, Australia.

The experiment was laid out in a split plot design with optimum moisture and moisture stressed environments as main plot factor and 60 wheat genotypes as sub-plot factor. Each set of experiment was replicated three times. Plastic bins (n=360) of 12 cm diameter and 30 cm depth, purchased from the local market were used to raise wheat germplasms in the greenhouse. Daily temperature and relative humidity of the greenhouse were taken. The minimum, maximum, mean air temperature and relative humidity recorded during the water stress imposed period of the experiment is shown in figure 1.

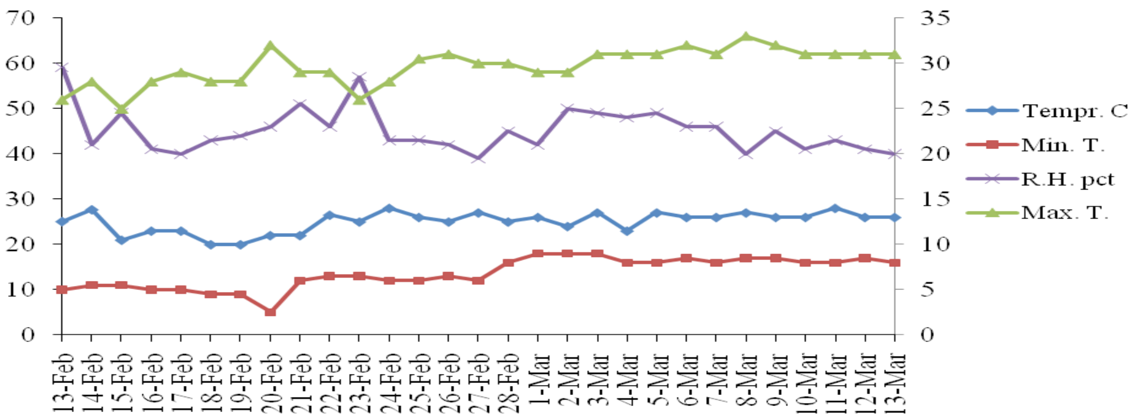

Figure 1. Minimum, maximum and mean temperature and relative humidity of greenhouse during the research, 2009

Each pot was filled with 7.5 kg of sandy loam soil (moisture content at 75% field capacity) taken from the wheat-growing field of IAAS research farm. Three seeds of each germplasm were sown in each pot on December 6, 2009. Thinning was done on January 6, 2010 and single seedling of each line was maintained in each pot. All the pots of irrigated set were watered weekly to maintain initial soil moisture content (sandy loam with 75% of field capacity), i.e. 7.5 kg weight throughout the experiment. For moisture stressed experiment, soil moisture content was maintained at 35 percent of field capacity (6.5 kg soil weight) by withholding watering at tillering (growth stage 20, Zadok scale) until harvested at flowering stage (growth stage 60, Zadok scale). The plants were harvested at flowering stage as our aim was to assess morpho-physiological traits for drought tolerance.

Observations were taken for morpho-physiological characteristics. Water use, water use efficiency, relative water content were physiological characteristics whereas number of tillers per plant, plant height, phenological period and biomass production per plant were morphological traits. Plant height was measured from the soil surface in centimeters (cm) up to the height of the top of the uppermost spikelet at the harvesting time. Days to booting, heading and anthesis were recorded. Biomass yield per plant was determined as gram (g) per plant in which above ground biomass yield was taken at the flowering stage for both moisture stressed and irrigated conditions. The number of effective tillers per plant was determined at the flowering stage of wheat (growth stage 60, Zadok scale).

Water use by different wheat genotypes were estimated by weighing the pot on a weekly interval. Evapo-transpiration was recorded for each pot regularly and the amount of water transpired by the plants was estimated based on six evaporation control pots randomly placed in the greenhouse. In addition, for water use efficiency the biomass weight from each plant was divided by the water use per plant to get the water use efficiency. Water use efficiency = Biomass production / Water use.

At booting stage flag leaf was excised in morning hours, cut into 12 cm leaf sections and fresh weight (FW) determined. Then leaf sections were sliced into 2 cm pieces; soaked in distilled water for 4 hours. The turgid leaf pieces were then rapidly blotted to remove surface water and weighted to obtain the turgid weight (TW). The samples were dried for 48 hours at 60˚C in a oven and dry weight (DW) determined. RWC percent was calculated as: [(FW-DW)/(TW-DW)]×100.

Data were processed in the Microsoft Office Excel 2007. Analysis of variance and means were computed with GENSTAT software (Discovery Edition package) developed by VSN International. Paired t-test (was used to analyze the difference between the moisture stressed and not stressed condition) and correlation analysis was done with SPSS 16.

3. Results and Discussion

The days to booting, days to heading and days to anthesis of wheat evaluated under the optimum moisture regime were 73, 81 and 83, respectively whereas it was 69, 77 and 80 under the moisture stressed conditions. Days to booting in moisture stressed and optimum moisture environment was shown in figure 2. Analysis of variance reveled that there is a highly significant differences among the genotypes used in this experiment (Table 2). The phenological parameters in the two contrasting moisture regimes were statistically highly significant (Table 3). Olivares-Villegas et al. (2007) found reduction in days to booting, heading and anthesis in wheat crop by 10% in moisture stress condition. Reduced growth duration is associated with reduced leaf number (Blum, 2005). Early flowering has been associated with drought escape in spring wheat in environments subjected to severe early season drought stress.

Table 2: Mean squares of ANOVA of morphological traits as influenced by moisture regime and genotypes in greenhouse, Rampur, Chitwan, 2009

Source	Df	Days to booting	Days to heading	Days to anthesis	Biomass production	Plant height	No. of tillers
Replication	2	3.17	17.72	23.508	0.727	1161.21	1.433
Moisture regime (A)	1	1472.18	1625.62**	1037.003*	3009.67**	16889.12	41.344*
Error (a)	2	8.25	16.97	5.019	12.326	795.007	2.211
Genotypes (B)	59	65.96**	46.95**	41.733**	21.573**	1056.06**	1.459**
A×B	59	14.41	3.44	4.110	5.99**	1140.11	0.841
Error (b)	236	17.39	16.17	9.377	3.588	1026.87	0.926

*, ** Significant at 0.05 and 0.01 probability levels, respectively. Df: Degree of freedom

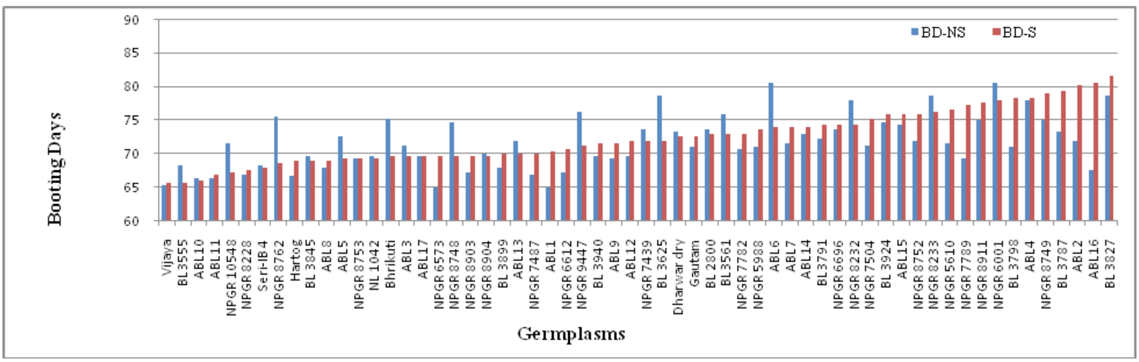

Figure 2. Booting days of 60 different wheat germplasms recorded for optimum (BD-NS) and moisture stressed (BD-S) environment. The genotypes are arranged (L to R) in increasing order of booting days in moisture stressed environment.

Table 3: Mean squares of ANOVA of physiological traits as influenced by moisture regime and germplasms in greenhouse, Rampur, Chitwan, 2009

Source	Df	Water use	Biomass production	WUE	RWC
Replication	2	0.1287	0.727	9.493	697.10
Moisture regime (A)	1	108.1**	3009.67**	306.02**	1897.43
Error (a)	2	0.1061	12.326	3.361	199.18
Germplasms (B)	59	0.1156**	21.573**	17.078**	150.24**
A×B	59	0.111**	5.99**	12.498**	217.04**
Error (b)	236	0.0617	3.588	3.755	61.22

*, ** Significant at 0.05 and 0.01 probability levels, respectively. Df: Degree of freedom; WUE: Water use efficiency; RWC: Relative water content

Table 4: Significance test of environment means for the selected morpho-physiological traits in 60 wheat genotypes

Treatments	Water use (l)	Biomass production (g)	Water use efficiency (g/l)	RWC (%)	Plant height (cm)	Number of tillers
Irrigated mean	1.8565	12.3543	5.5792	73.0629	64.1544	2.3889
SEM	0.03437	0.45101	0.23677	1.14634	0.85158	0.9005
Drought mean	0.7606	6.5715	7.2153	68.4713	57.0961	1.7111
SEM	0.00887	0.18938	0.19906	0.85227	0.66660	0.06837
t- value	31.187**	11.832**	-6.318**	2.957*	6.911**	7.009**

, * Significant at 0.05 and 0.01 probability levels, respectively.

The plant height of wheat genotypes was highly significant (Table 2). The genotypes were highly significant for optimum moisture and stressed conditions (Table 4). The average value of plant height under non-stressed conditions was 64.15 cm whereas it was 57.09 cm under drought conditions. All the genotypes were found taller under non-stressed conditions. Genotypes namely Gautam, Hartog and Vijaya were found taller; Bhrikuti was medium; Dhawar dry and SeriM82 were shorter in height. Olivares-Villegas et al. (2007) found large difference in the plant height in response to the reduced soil water availability and the range in height reduction under drought conditions varied from 10 to 53 percent, a reduction paralleled by a yield decrease.

Drought had a pronounced effect on number of tillers per plant. The number of tillers for the wheat genotypes was found highly significant (Table 2) and also for optimum and moisture stressed conditions (Table 4). The average number of tillers under irrigated conditions was 2.38 whereas 1.71 under stressed conditions. Genotypes, SeriM82, and Vijaya had less number of tillers, Gautam average and Bhrikuti, Hartog and Dhawardry had higher number of tillers for both the moisture regimes. However, there was a reduction of tillers by 13 percent on an average under moisture stressed conditions. Early water stress in barley was found to damage the number of tillers which strongly reduced yield potential (Sahnoune et al., 2004).

The mean flag leaf area for different genotypes of wheat was found highly significant and also for the two different moisture regimes (data not shown). The average flag leaf area were 28.4116 cm^2, 22.9950 cm^2 under optimum moisture and moisture stressed conditions. Genotypes and moisture regime interaction was also highly significant, suggesting genotypic variations for flag leaf area with moisture. On an average, 13.10 percent decrease in flag leaf area was found due to moisture stress. Leaf growth inhibition is among the earliest response to drought (Chaves et al., 2003). Drought and heat stress causes reduction in total leaf area due to reduced leaf length and leaf breadth (Ubaidullah et al., 2006). Water stress reduces the growth of plants by reducing the photosynthetically active leaf area, the most important factor affecting crop productivity (Dubey, 1997).

The relative water content (RWC) of the wheat genotypes under moisture stressed conditions ranged from 45.5 to 82.1 percent (Fig. 3). The genotypes with high RWC under moisture stress were NPGR 8752, Vijaya, BL 2800 and Gautam; Nepalese commercial cultivar Bhrikuti and Dhawar dry were moderate; whereas Hartog, seriM82 and NPGR 8749 had lowest RWC. The germplasms with higher RWC under moisture stressed conditions were able to maintain the transportation of assimilates and can then increase the yield even under the drought conditions and therefore will have drought tolerance characteristics.

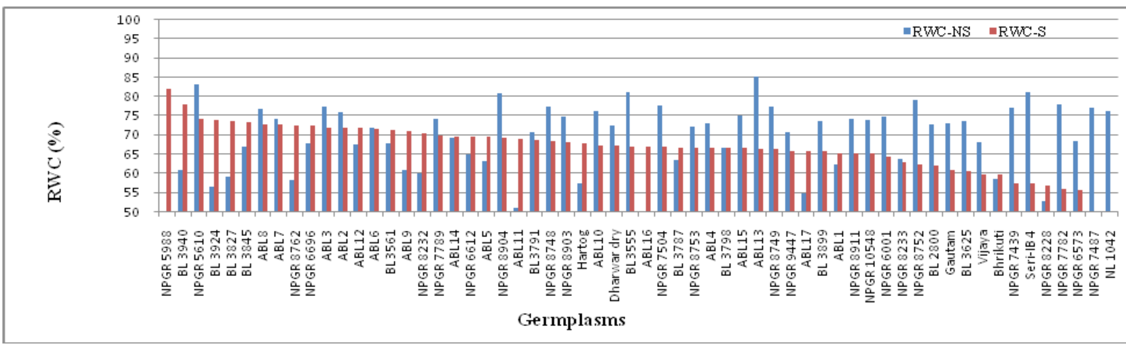

Figure 3. Relative water content of 60 wheat genotypes measured under optimum (WU-NS) and moisture stressed (WU-S) environments. The genotypes are arranged (L to R) in decreasing order of RWC value under moisture stressed environments.

The amount of water used (WU) by different genotypes of wheat under optimum moisture environments ranged from 1266 to 2390 ml, whereas under moisture stressed environments, WU ranged from 606 to 880 ml (Figure 4). The genotype vs. moisture regime interaction for WU was highly significant (Table 3), indicating water use pattern of genotypes changed with water availability. This is in conformity with result of Dodig et al. (2008). BL2800, Gautam, Hartog, and Dharwar dry had higher WU values under non-stressed environment in contrast to SeriM82, NPGR6696, Vijaya and Bhrikuti, which used minimum water during the test period.

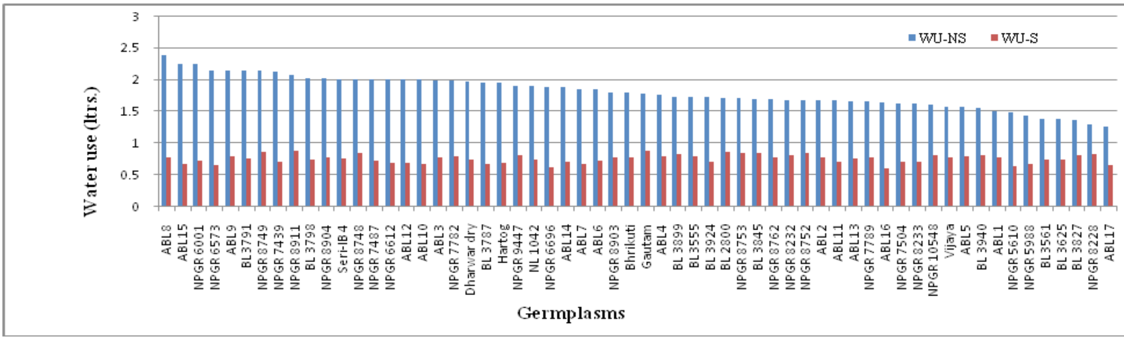

Figure 4. Water use (ml) by the 60 wheat genotypes measured under optimum (WU-NS) and moisture stressed (WU-S) environments. The genotypes are arranged (L to R) in decreasing order of WU values under optimum moisture environments.

The amount of biomass produced by different genotypes of wheat was found highly significant (Table 2) and also for optimum and moisture stressed conditions (Table 4). The average biomass weight was 12.3543 g under optimum moisture conditions whereas it was 6.5715 g under stressed conditions. The biomass production ranged from 3.52 to 17.82 g under non-stressed environments and 3.26 to 7.43 g under moisture stressed environments. The mean biomass produced by the wheat genotypes under moisture stressed environments was significantly lower than that under non-stressed environments. Under optimum moisture, NPGR 8762, ABL17 and Gautam had the highest biomass. Similarly, in moisture stressed condition, NPGR 8753, NL1042 and Gautam had the highest biomass. The drought tolerant Indian landrace Dharwar dry and Nepalese cv. Vijaya had average biomass, whereas, NPGR 8753, ABL12 and NPGR 8228 had minimum biomass production. Reduction in biomass due to moisture stress had been reported by Zhu et al. (2008).

The water use efficiency (WUE), estimated as dry matter produced (g) per unit of total water (lit), varied from 4.1804 to 11.276, and 2.285 to 11.650 under moisture stressed and optimum moisture environments, respectively (Fig. 5). The expression of WUE was more pronounced under moisture stressed environments. In the present study, the most water use efficient wheat genotypes were NPGR 7789, NPGR 6001, ABL7 and ABL3. The popular cv. Gautam was found water use efficient, whereas Bhrikuti, SeriM82 and Dharwar dry were found moderate. The Australian cultivar Hartog, NPGR 6573 and Nepalese cv. Vijaya were characterized poor in WUE. The expression of WUE was more pronounced under moisture stressed environment. Similar results with improved WUE of winter wheat cultivars grown with limited irrigation has been reported by Zhang et al. (1998) and Poormohammad et al. (2007) in sunflower. It is worthwhile to mention that ABL3, NL1042 and Bhrikuti were highly water use efficient under moisture stressed conditions, however, showed a high level of genotype x environment interaction for WUE. Manschadi et al. (2007) characterized the CIMMYT line SeriM82 and Dharwar dry as drought tolerant and Hartog as a drought sensitive in Australia. The WUE estimated for these genotypes in this experiment also indicated for a similar pattern of drought adaptation (Fig. 5).

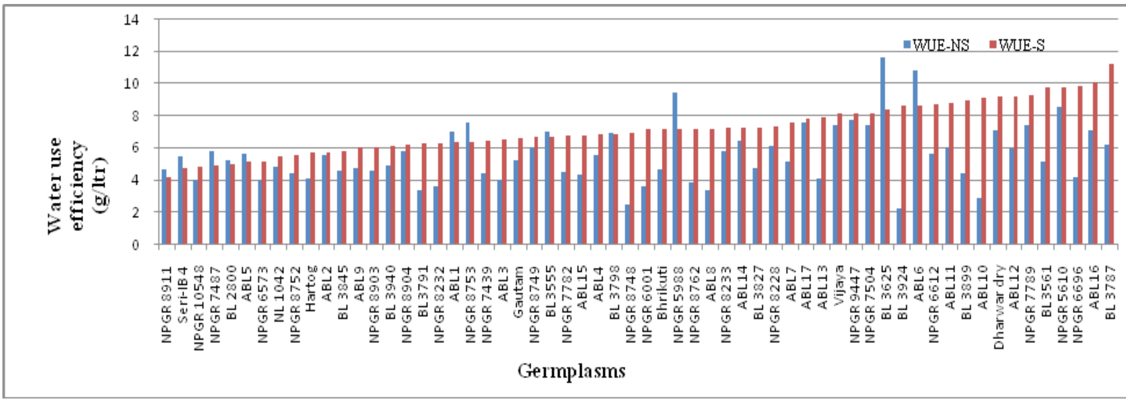

Figure 5. Water use efficiency (g dry wt./lit) of the 60 genotypes assessed in optimum WUE-NS) and moisture stressed (WUE-S) environment. The genotypes are arranged (L to R) in increasing order of WUE values under stressed environments.

Water use, water use efficiency, biomass yield and flag leaf relative water content are the important drought adaptive morpho-physiological traits in wheat (Richards et al., 2002, Rampino et al., 2006). Pearson's correlation study of the selected physiological traits under moisture stressed and normal condition was presented in table 4. Water use was positively correlated and highly significant with relative water content (RWC) (0.392), flag leaf area (0.273), plant height (0.455), and tiller number (0.413). In addition, water use was negatively correlated with anthesis days (-0.018) and highly significant negative correlation water use efficiency (-0.381).

Biomass production was highly significantly positive correlated with water use efficiency (0.607) and negative correlated with RWC. Booting days was highly significant and positively correlated with flag leaf area (0.377). Anthesis days was highly significant and positively correlated with heading days (0.676) and with booting days (0.674). Anthesis days was significant and positively correlated with the number of tillers (0.296).

In the case of moisture stressed conditions, water use was positively correlated with RWC, booting days and anthesis days. However, it was highly significant and negatively correlated with WUE (-0.518) and negative correlation with heading days and biomass production. Water use was highly significant and positively correlated with flag leaf area (0.505), plant height (0.523), and was significant and positively correlated with number of tillers (0.262).

Biomass production was highly significant and positively correlated with WUE (0.578). WUE is highly significant and negatively correlated with flag leaf area (-0.364) and plant height (-0.354). Flag leaf area was highly significant and positively correlated with flag leaf length (0.760) (data not shown). Similar findings were also reported by Munir et al. (2007).

Booting days were highly significant and positively correlated with heading days (0.513) and anthesis days (0.589). Heading days was highly significant and positively correlated with anthesis days (0.905). Tillers per plant were positively correlated with almost all the traits studied in this study for both the moisture regimes except with flag leaf area of both moisture regime condition, biomass production under moisture stressed conditions and WUE under moisture conditions.

Table 4: Correlation study of selected drought adaptive morpho-physiological traits for drought screening in greenhouse, Rampur, Chitwan, 2009/10

	WU S	BM S	WUE S	RWC S	FLA S	PHT S	BD S	HD S	AD S
	WU NS	BM NS	WUE NS	RWC NS	FLA NS	PHT NS	BD NS	HD NS	AD NS
BM S	-0.198								
BM NS	0.133								
WUE S	-0.518**	0.578**							
WUE NS	-0.381**	0.607**							
RWC S	0.039	0.054	0.25						
RWC NS	0.392**	-0.78	-0.219						
FLA S	0.505**	-0.209	-0.364**	-0.247					
FLA NS	0.273**	0.212	0.009	0.113					
PHT S	0.523**	0.023	-0.354**	-0.062	0.289*				
PHT NS	0.455**	0.119	-0.119	0.143	0.182				
BD S	0.077	0.027	0.139	0.097	0.099	0.175			
BD NS	0.93	-0.24	0.002	0.094	-0.052	0.377**			
HD S	-0.035	-0.063	0.103	0.003	0.18	-0.03	0.513**		
HD NS	0.018	-0.44	0.043	0.098	-0.014	0.245	0.676**		
TN S	0.262*	-0.175	0.023	0.177	-0.019	0.166	0.25	0.182	0.16
TN NS	0.413**	0.144	-0.075	0.111	-0.076	0.263*	0.295*	0.322*	0.296*

***, **;** Significant at 0.05 and 0.01 probability levels, respectively**.** (S: Moisture Stressed condition and NS: optimum moisture condition).

WU: Water use; BM: Biomass weight; WUE: Water use efficiency; RWC: Relative water content; FLA: Flag leaf area, PHT: Plant height; BD: Booting days; HD: Heading days; AD: Anthesis days; TN: Tiller number.

4. Conclusion

Landraces and advanced breeding lines of wheat exhibited a wide range of variabilities for drought adaptive morphophysiological traits. Water use efficiency was found the most effective trait for higher biomass yield. Among Nepalese commercial cultivars, Gautam was found superior and Bhrikuti average for drought adaptability, whereas Vijay was drought sensitive.

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Information Seeking and Utilization Behavior of Commercial Vegetable Farmes of Chitwan and Dhading Districts of Nepal

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Abstract:

A study was conducted to examine the information seeking and utilization behavior of commercial vegetable farmers of Chitwan and Dhading district of Nepal to generate information that help to develop effective communication process in order to improve the communication system for both the information providers and commercial vegetable farmers. The study was conducted using descriptive survey research design, selecting the study districts purposively on the basis of more land area been used in vegetable cultivation. Seventy five respondents were selected randomly in each district, to make a sample size of 150. Data were collected by using face to face interview method and analysed by using descriptive and appropriate inferential statistics. Findings showed the present information needs of the farmers were: improved varieties and seeds, fertilizers and micronutrient use, disease and insect incidence forecast, plant protection measures, wholesale market price of vegetable and the quantity traded in the market. There was greater reliance on local informal sources with the minimum use of official sources and media in getting information on commercial vegetable production practices and marketing. The farmers gave high credibility and preference to local informal sources that were within their access and easy contact as compared to official sources and media. The access to information technology was changing localite information seeking behavior to cosmopolite behavior of farmers. Personal characteristics such as ethnicity, education, farming experience, personal facilities of communication, land area allocation to vegetable cultivation, number of vegetables cultivated, and income from vegetable sell were positively correlated with information seeking and utilization behavior of farmers. However, terrain condition and age had negative relation with information seeking level of farmers. This study suggests that information providing institutions should use local informal sources of information as far as possible to deliver information to commercial vegetable farmers.

Key words: Agricultural information, information needs, sources credibility and preference, information seeking and using

1. Introduction:

The agriculture system of Nepal is gradually shifting from subsistence to commercial farming (NPC, 2007). Many farmers previously engaged in cereal crops production shifted to commercial vegetable production within the last one decade and this change is especially visible in the periphery of highway corridors. With considerable efforts of government and private sectors resulting in an appreciable increase in vegetable productions; some problems still exist as production potentiality gap and effective marketing of vegetables. These problems can be expressed in terms of the gap between the availability of research based scientific knowledge and its dissemination and utilization in commercial vegetable production at farm level. Information is a critical resource in the operation and management of farm and solving problems of production, productivity and marketing. Timely availability of relevant information is vital for effective performance of managerial functions (Babu, et al. 1997, in Pezeshki-Rad and Zamani 2005) in the farming.

The three components of agriculture information system- information generation, information dissemination and information utilization, are equally important for commercialization of agricultural sector. However, in the present information era, due to availability of scientific equipment and technology, the information generation and dissemination are not the real challenging tasks, but getting farmers to use information efficiently in making production, marketing and financial decisions related to their farm business are the real challenges. Farmers use different information sources to get information supportive in making production and marketing decisions. However, their information behavior, which is the totality of human behavior in relation to information including seeking and using information (Wilson, 2000), is often influenced by their information needs (Wilson, 2000), source credibility (Singh and Sahay, 1970, Tiwary and Joshi, 1993), personal characteristics (Tiwary and Joshi, 1993, Suvedi et. al. 1999, Gunawardana and Sharma, 2007), nature of information- accuracy, sufficiency, reliability, and timeliness, as well as characteristics of sources like type, accessibility and credibility, personal work role, discipline, and organization involved (Wilson 1994). Considering the dynamics of entire communication process over time it is, therefore, essential to understand the information seeking and utilization behavior of commercial vegetable farmers. A critical analysis of farmers information behavior in terms of use of modern Information Technology (IT) and constraints of access and use of information could be helpful in identifying the ways and means of farmers' needs based information generation and dissemination to commercial vegetable farmers. This study was designed to analyze and describe the information behavior of commercial vegetable producing farmers at two locations midhill and Terai (Dhading and Chitwan) in lieu of terrain differences.

2. Research Methodologies

This study was done in Chitwan and Dhading districts using descriptive sample survey research design. Fourteen VDCs from two districts were selected purposively on the basis of more vegetable production area and accessibility to the researcher. The detail information on the number of commercial vegetable farmers in Chitwan and Dhading was not available in DADO, VDC, Agriculture Service Center and farmers' cooperatives level. Therefore the researcher decided to take a sample of 150 commercial vegetable farmers from Chitwan and Dhading as respondents of representative sample of this research study. Then, 75 commercial vegetable farmers were randomly selected from Chitwan and 75 from Dhading district from vegetable pocket area of selected VDCs as sample for the study.

Secondary data were collected from District Agriculture Development Office of Chitwan and Dhadhing. Primary data were collected by using a precise questionnaire consisting of open ended and closed ended questions. Distributive and descriptive statistics with appropriate statistical tests were used for data analysis. Non-parametric statistics such as correlation analysis and Chi-square test were used to determine relative effects of different independent variables on study variables (information seeking and utilization behavior) and to make comparison in different characteristics of the respondents in Chitwan and Dhading districts wherever necessary.

3. RESULTS AND DISCUSSION

3.1. Information needs of the respondents

The information needs of commercial vegetable farmers were studied by asking the respondents to rate the information by using scale values of 4, 3, 2, and 1 as most needed, much needed, needed, and less needed respectively as perceived by them. Later on, total score, mean score and mean of the means were computed. On the basis of the mean score the technical, marketing and meteorological information needs were ranked as presented in Table 1.

Table 1: Present information needs of the commercial vegetable farmers by districts, 2009.

Types of information	Frequency	Chitwan	Dhading	Total		Rank
		Mean	Mean	Mean	SD	
Technical	150 (100.0)	2.45	2.22	2.33	0.67	III
Marketing	99 (66.0)	2.32	2.42	2.36	0.94	II
Meteorological	116 (77.3)	2.49	2.74	2.63	0.92	I

Figures in parenthesis are in percentage

Table 1 revealed that all commercial vegetable (CV) farmers needed meteorological information followed by marketing and technical information. In meteorological information CV farmers mostly desired to get information on forecast of disease and insect incidence. In case of marketing information they demanded daily wholesale price of vegetables followed by quantity traded, export potential and quantity of vegetables imported. In technical information CV farmers of both districts demanded the information on improved varieties and seeds (improved and hybrid varieties and seed quality) followed by plant protection measures, fertilizers and micronutrient application techniques.

3.2. Information sources used at the beginning period of commercial vegetable farming by respondents

The information sources used at the beginning period of CV production was studied by asking the respondents to rate information sources used on the scale values of 5, 3, and 1 as most, much, and less frequently used respectively. Later on the total rank score for each source was computed and the sources were ranked on the basis of total score.

Table 2: Information sources used at the beginning of CV production by respondents by districts, 2009

Sources of information	No. of respondents			Total Score	Rank	Overall rank
	Chitwan	Dhading	Total			
Formal sources						
Research scientist	1 (1.3)	5 (6.7)	6 (4.0)	30	III	X
DADO personnel	26 (34.7)	18 (24.0)	45 (30.0)	217	I	III
INGO/NGO	0 (0.0)	1 (1.3)	1(0.7)	5	IV	XII
Farmers' group/ cooperative	7 (9.3)	0 (0.0)	7(4.6)	31	II	IX
Informal sources						
Neighbours	47 (62.6)	43 (57.3)	90 (60.0)	440	I	I
Friend	7 (9.3)	0 (0.0)	7 (4.6)	33	V	VIII
Other experienced and knowledgeable farmers	28 (37.3)	35 (46.3)	63 (42.0)	297	II	II
Agrovet	23 (30.7)	7 (9.3)	30 (20.0)	142	III	IV
Relative	4 (5.3)	11 (14.7)	15 (10.0)	75	IV	VI
Group/Mass Media						
Radio	9 (12.0)	10 (13.3)	22 (14.6)	104	I	V
Television	5 (6.7)	0 (0.0)	5 (3.3)	21	III	XI
Training	10 (13.3)	1 (1.3)	11 (7.3)	51	II	VII

Figures in parenthesis are in percentage

The data analysis on information sources used at the beginning of CV production by respondents showed that the informal sources ($\bar{x}$ =197.4) were the major sources of information followed by formal sources ($\bar{x}$ =70.75), and group and media sources ($\bar{x}$ =58.6) for CV farmers of both districts. The data in Table 2 revealed that of the several sources, neighbours ranked the first followed by other experienced farmers of the locality. However the DADO personnel, the most important formal source of research based agricultural information, ranked third as sources of CV production information. The use of more informal sources was because of high accessibility to and easy to interact with local sources of information. Radio was the important source among the group/mass media used by farmers at the initial stage of CV production.

3.3. Information media and sources presently used for technical information

The results of analysis of the data of technical information sources used by the respondents of Chitwan and Dhading are presented in the Tables 3.

Table 3: Media, Sources and types of information presently used by respondents, 2009

Sources	Types of Technical information				
	New varieties and seed	Cultivation technique	Plant protection measures	Fertilizers and micronutrients application	Post harvest handling
Formal sources					
Official sources	6 (3.2)	5 (4.2)	25 (12.3)	3 (1.8)	1 (4.2)
Group /Cooperatives	19 (10.1)	9 (7.6)	15 (7.4)	16 (9.7)	4 (16.7)
Informal sources					
Local farmers	25 (13.3)	32 (26.9)	32 (15.8)	11 (6.7)	16 (66.7)
Agri-business and dealers	138 (73.4)	71 (59.7)	128 (63.1)	135 (81.8)	2 (8.3)
Media					
Media and channel	0 (0.0)	2(1.6)	3 (1.5)	0 (0.0)	1 (4.2)
Total responses	188 (100)	119 (100)	203 (100)	165 (100)	24 (100)

Figures in parenthesis are in percentage

It was obvious from the data in Table 3 that overall uses of the sources and media by the CV producers still more frequently used the local sources of information for technical information on CV production practices. Among the local sources agri-business and dealers were mostly used followed by local farmers and CV groups/cooperatives. Formal/official sources were comparatively less used and media was the least utilized in obtaining technical information on the cultural practices of CV production. It implied that local facilities for communication needed to be more strengthened as they were within easy access and contacts specially the local institutions of which CV producers would be mostly members. It is the establishment of ICT center in rural area.

As far as the types of technical information were concerned among the CV production practices information on plant protection measures, varieties and seeds, fertilizers and micronutrients application, and production technique were the areas in which most information was sought.

The CV producers of Chitwan used more sources of information on CV production practices in comparison to Dhading farmers. Dhading farmers mostly used agri-business and dealers for different types of information. It seems that Dhading farmers were more localite in using information sources on CV production. However Chitwan farmers were slightly more cosmopolite in information sources used on CV production. This is due to easy access to information sources in Chitwan.

3.4. Information media and sources used for marketing information by respondents

The analysis of marketing information sources used indicated that respondents got market wholesale price, and quantity traded in the market information from 5 different sources which was presented in Table 4.

Table 4: Information sources used by respondents for marketing information by districts, 2009

Types of sources	Types of information					
	Wholesale price			Quantity traded		
	Chitwan	Dhading	Total	Chitwan	Dhading	Total
Cooperative/group	9 (9.6)	11 (8.9)	20 (9.2)	4 (5.2)	2 (3.0)	6 (4.2)
Other farmers	17 (18.1)	23 (18.5)	40 (18.3)	10 (13.0)	8 (12.1)	18 (12.6)
Vegetable collection and trading center	22 (23.4)	33 (26.6)	55 (25.2)	22 (28.6)	33 (50.0)	55 (38.5)
Phone call to vegetable wholesale market	42 (44.7)	37 (29.8)	79 (36.2)	41(53.2)	23 (34.8)	64 (44.8)
Radio Nepal	4 (4.3)	20 (16.1)	24 (11.0)	0 (0.0)	0 (0.0)	0 (0.0)
Total	94 (43.1)	124 (56.9)	218 (100)	77 (53.8)	66 (46.2)	143 (100)

Figures in parenthesis are in percentage

Table 4 revealed that among five sources of marketing information, the more respondents got both types of marketing information by making phone call to vegetable wholesale market and wholesale traders. The second important source of vegetable marketing information was local level vegetable collection and trading center. This is due to the most of the respondents sold their products to local level vegetable wholesale purchaser at vegetable collection and trading centre in their locality and they know the wholesale price and quantity traded in that place. In district wise comparison Dhading farmers used a slightly more information sources to get marketing information. It seems that they had higher level of awareness about vegetable marketing information than Chitwan farmers.

3.5. Credibility of information sources perceived by the respondents

Source credibility operationally means a degree of trustworthy and fairness accorded to a source of information by its user at a given time. The respondents were asked to rate the credibility of the information sources they have been using on the scale values of 5, 3 and 1 for most credible, much credible and less credible as perceived by them. Total score of each source was derived by addition of all the value given by each respondent. The sources were ranked on the basis of total score.

3.5.1. Technical information source credibility

The results of technical information source credibility were presented in Table 5 below.

Table 5: Credibility of technical information sources perceived by the respondents by districts, 2009

Information sources	Number of respondents			Source credibility		
	Chitwan n= 75	Dhading n= 75	Total n= 150	Score	Rank	Overall rank
Formal sources						
Official sources	28 (37.3)	24 (32.0)	52 (34.3)	240	I	V
Farmers group/ cooperatives	12 (16.0)	19 (25.3)	31 (20.7)	139	II	VII
Informal sources						
Neighbours	30 (40.0)	38 (50.6)	68 (45.3)	316	II	IV
Other experienced farmers	31 (41.3)	22 (29.3)	53 (36.0)	238	III	VI
Agri-business and dealers (Agrovets)	72 (96.0)	61 (81.3)	133 (88.7)	603	I	I
Media						
Radio	36 (48.0)	59 (78.7)	95 (63.3)	361	I	II
Television	34 (45.4)	51 (68.0)	85 (56.7)	355	II	III
Mobile phone	5 (6.7)	1 (1.3)	6 (4.0)	26	VI	XI
Printed material	8 (10.7)	1 (1.3)	9 (6.0)	41	V	X
Tour and visit	11 (14.7)	3 (4.0)	14 (9.3)	52	IV	IX
Training	15 (20.0)	6 (8.0)	21 (14.0)	95	III	VIII
Exhibition	4 (5.3)	0 (0.0)	4 (2.7)	18	VII	XII

Figures in parenthesis are in percentage

The data in Table 5 indicated that of the several sources, the agri-business and traders (agrovets) were given maximum credibility followed by radio, television, and neighbours as technical information sources. The extension personnel ranked into fifth credible source of technical information. It seems that informal sources and media are playing an important role in sharing and delivery of technological information to commercial vegetable farmers. In case of media sources radio secured slightly a higher score than television. This is due to electricity problem and high affordability of radio in comparison to television. The least credible sources were exhibition, mobile phone, printed material and tour/visit.

3.5.2. Marketing information sources credibility

The results of credibility of marketing information sources were given in Table 6.

Table 6: Credibility of marketing information sources perceived by the respondents by districts, 2009

Information sources	Number of respondents			Source credibility		
	Chitwan n= 75	Dhading n= 75	Total n= 150	Score	Rank	Overall rank
Formal sources						
Farmers group/ cooperatives	7 (9.3)	19 (25.3)	26 (17.3)	122	I	IV
Informal sources						
Neighbours	15 (20.0)	0(0.0)	15 (10.0)	57	IV	VIII
Other farmers	7 (9.3)	10 (13.3)	17 (11.3)	71	III	VII
Business and dealers (Agrovets)	68 (90.7)	57 (76.0)	125 (83.3)	577	II	II
Vegetable wholesale traders	69 (92.0)	69 (92.0)	138 (92.0)	652	I	I
Media						
Radio Nepal	33 (44.0)	40 (53.3)	73 (48.7)	235	I	III
Television	6 (9.0)	0 (0.0)	6 (4.0)	26	III	IX
Mobile phone	8 (10.7)	18 (24.0)	26 (17.3)	116	II	V

Figures in parenthesis are in percentage

Table 6 revealed that among the several sources the agri-business and dealers were given high credibility followed by cooperatives for inputs marketing. For vegetable products marketing farmers were given maximum credibility to vegetable wholesale traders followed by wholesale price bulleting program of Radio Nepal, and farmers' group/vegetable cooperatives. The least credibility was given to television as source of marketing information.

3.6. Preference of information sources by the respondents

The preference of sources of information operationally means the willingness of farmers to receive the information among the available sources to meet their information needs. To measure the respondents preference of source of information, the respondents were asked to rate the source with values of 5, 3, and 1 for most preferred, much preferred and less preferred respectively. The total score of each source was derived from summing up of all the values given by respondents. Later on each source of information was ranked on the basis of total value secured by each source and presented as in Table 7 and Table 8.

3.6.1. Preference of technical information sources

The results of source preference of respondents to get technical information were presented as follows.

Table 7: Sources preference of the respondents to get technical information by districts, 2009

Information sources	Number of respondents			Source preference		
	Chitwan n= 75	Dhading n= 75	Total n= 150	Score	Rank	Overall rank
Formal sources						
Official sources	27 (36.0)	24 (32.0)	51 (34.0)	239	I	VI
Farmers group/ cooperatives	12 (16.0)	2 (2.7)	14 (9.3)	64	II	VIII
Informal sources						
Neighbours	33 (44.0)	19 (25.3)	52 (34.7)	240	III	V
Other experienced farmers	27 (36.0)	59 (78.7)	86 (57.3)	388	II	II
Business and dealers	70 (93.3)	61 (81.3)	131 (87.3)	597	I	I
Media						
Farm radio program	36 (48.0)	59 (78.7)	95 (63.3)	353	II	IV
Farm television program	34 (45.3)	51 (68.0)	85 (56.7)	355	I	III
Mobile phone	7 (9.3)	1 (1.3)	8 (5.3)	36	VII	XII
Printed material	9 (12.0)	1 (1.3)	10 (6.7)	44	IV	IX
Tour and visit	11 (14.6)	1 (1.3)	12 (8.0)	40	VI	XI
Training	15 (20.0)	2 (2.7)	17 (11.3)	77	III	VII
Exhibition	3 (4.0)	6 (8.0)	9 (6.0)	43	V	X

Figures in parenthesis are in percentage

The data in Table 7 indicated that among several sources of information agri-business and dealers were most preferred followed by other experienced farmers, farm television program, farm radio program, and neighbour to get technical information. It seems that farmers were preferred to local and media sources, which are in easy access of farmers, for technical information. In district wise analysis after localite sources, preference to official sources was a slightly higher in Chitwan whereas media sources preferred more in Dhading. This is due to accessibility to sources. This indicated that farmers preferred those sources which are within their easy access.

3.6.2. Preference of marketing information sources

Farmers can get marketing information from ten different sources. Among these sources the respondents gave their responses only in eight sources as their preference to get marketing information and the results were presented as follows.

Table 8: Sources preference of the respondents to get marketing information by districts, 2009

Information sources	Number of respondents			Source preference		
	Chitwan n= 75	Dhading n= 75	Total n= 150	Score	Rank	Overall rank
Formal sources						
Farmers group/ cooperatives	8 (10.7)	19 (25.3)	27 (18.0)	127	I	IV
Informal sources						
Neighbours	14 (18.7)	0 (0.0)	14 (9.3)	52	IV	VII
Other farmers	7 (9.3)	10 (13.3)	17 (11.3)	71	III	VI
Business and dealers (Agrovets)	68 (98.7)	57 (76.0)	125 (83.3)	573	II	II
Vegetable wholesale traders	70 (93.3)	69 (92.0)	139 (92.7)	657	I	I
Media						
Radio Nepal	35 (46.7)	40 (53.3)	75 (50.0)	229	I	III
Television	6 (8.0)	0 (0.0)	6 (4.0)	28	III	VIII
Mobile phone	7 (9.3)	18 (24.0)	25 (16.7)	117	II	V

(Figures in parenthesis in percentage)

Among the preferred sources for marketing information most preferred one was vegetable traders followed by agri-business and dealers, Radio Nepal, and CV farmers' cooperatives. The least preferred source was television. Farmers preferred vegetable wholesale traders for information of vegetable wholesale price and quantity of vegetable possible to be sold in the market. The agri-business and dealers were preferred to get information about inputs price and quantity available to purchase. Third preferred source was Radio Nepal which broadcast daily wholesale price of vegetables and fruit in Kalimati Vegetable and Fruit Wholesale Market, Kathmandu. The main market of vegetables produced in Chitwan and Dhading is Kalimati wholesale market. Therefore farmers preferred to know daily wholesale price of vegetable in Kalimati market and preferred Radio Nepal's price bulletin as sources of marketing information.

3.7. Gender involvement in information seeking activities

Both men and women involved in the CV production in both districts so that their information needs are also similar. Therefore both men and women need to get information and utilize in CV production. To analyse gender wise involvement in the information seeking for CV production the respondents were asked who did the information seeking work in their house and what are the reasons of either only man or woman involvement in getting information from different sources. The results of gender wise involvement in getting information for CV production were presented in Table 9.

Table 9: Gender involvement in information seeking by districts, 2009

	Information seeker	Number of respondents		
		Chitwan	Dhading	Total
Gender	Man	53 (70.7)	54 (72.0)	107 (71.3)
	Woman	6 (8.0)	7 (9.3)	13 (8.7)
	Both man and woman	16 (21.3)	14 (18.7)	30 (20.0)
	Total	75 (50.0)	75 (50.0)	150 (100)

Figures in parenthesis are in percentage

Table 9 revealed that information seeking role was done more by men in the respondents' household. The women were still depended on men for CV production information in both districts. The role of information seeking assigned more on men because of their experience (40.3 %) in contacting to information sources and free to go outside (43.8 %).The analysis of several activities of information seeking done by men and women revealed that except watching farm television program all other activities were mostly done by men of the households. The activity of watching farm television program was done more by women (62.7 %) in overall. On the gender basis men were dominant in getting first hand information and women were depending on men for vegetable cultivation and marketing information.

3.8. Influence of farmers group and cooperatives in information seeking behavior of respondents

Participation in group and cooperatives increases social participation of farmers and that influences in their information seeking behavior. In group and cooperative farmers may share information on CV production with each other. The results of data analysis of group and cooperative influence in information seeking of CV producers were presented in Table 10 below.

Table 10: Influence of groups and cooperatives in information seeking of respondents by districts, 2009

Influence in information seeking		Number of respondents		Total
		Chitwan	Dhading	
Group	No	57 (76.0)	63 (84.0)	120 (80.0)
	Yes	18 (24.0)	12 (16.0)	30 (20.0)
	Total	75 (100.0)	75 (100.0)	150 (100.0)
Group sharing	Always	9 (12.0)	3 (4.0)	12 (8.0)
	Frequently	11 (14.7)	5 (6.7)	16 (10.7)
	When requested	1 (1.3)	3 (4.0)	3 (2.0)
Cooperatives	No	43 (57.3)	61 (81.3)	104 (69.3)
	Yes	32 (42.7)	14 (18.7)	46 (30.7)
	Total	75 (100.0)	75 (100.0)	150 (100.0)
Information from cooperatives	Production input	24 (75.0)	11 (78.6)	35 (76.1)
	Production technique	18 (39.1)	11 (23.9)	29 (63.0)
	Marketing information	9 (28.1)	4 (28.6)	13 (28.3)
	Total	51 (66.2)	26 (33.8)	77 (100.0)

Figures in parenthesis are in percentage

The data in Table 10 indicated that more respondents received information from cooperatives than groups. This is due to less numbers of respondents were the members of farmers groups than members of CV producers cooperative. The sharing of information among group members was also low in both districts. The CV producers mostly received production input information followed by production technique and marketing information from their cooperatives in both districts. However the numbers of respondents were more in receiving information from cooperative in Chitwan than Dhading. The vegetable cooperatives were providing technical information by organizing training to their members using extension personnel as training experts.

3.9. Use of mobile phone in getting information by respondents

The results of mobile phone used in getting information by respondents and types of information received were anlaysed and presented in Table 11 below.

Table 11: Use of mobile phone in getting information by respondents by districts, 2009

Use of mobile phone and types of information received	Number of respondents		Total	
	Chitwan	Dhading		
Mobile phone not used	12 (19.0)	8 (17.4)	20 (18.3)	$\chi2$= 4.669*
Mobile phone used	51 (81.0)	38 (82.6)	89 (81.7)	d.f. = 1
Total	63 (57.8)	46 (42.2)	109 (100.0)	
Information types				
Technological information from JT/JTA/SMS and research scientist	11 (13.9)	4 (9.0)	15 (12.2)	
Marketing information from market centers/ traders	52 (65.8)	38 (86.4)	90 (73.2)	
Input information from traders	16 (20.3)	2 (4.6)	18 (14.6)	
Total	79 (64.2)	44 (35.8)	123 (100.0)	

Figures in parenthesis are in percentage, * Significant at P<0.03

The analysis of data of mobile used in getting information by CV producers indicated that there was significantly lower level of mobile used in Dhading in comparison to Chitwan. The data in Table 11 indicated that the mobile phone was mostly used to get marketing information from vegetable market centers and traders and input traders in both districts. The technical information received by lower number of respondents might be due to cost of phone call in receiving information from official sources of districts.

3.10. Information utilization behavior of respondents

The Information utilization behavior of farmers included area of application of different information (technical, marketing and weather) in vegetable cultivation, and extent of sharing information with other farmers.

3.10.1. Technical information utilization behavior

The results of analysis of technical information used areas by CV farmers were presented in table 12.

Table 12: Areas of technical information used by respondents by districts, 2009

Areas of information use	No. of respondents		Total	
	Chitwan	Dhading		
	n = 75	n = 75	n = 150	
	Yes	Yes	Yes	No
Crop selection	19 (25.3)	6 (8.0)	25 (16.7)	125 (83.3)
Area allocation	11 (14.7)	3 (4.0)	14 (9.3)	136 (90.7)
Varieties selection	66 (88.0)	58 (77.3)	125 (83.3)	25 (16.7)
Doses and techniques of input use	66 (88.0)	70 (93.3)	136 (90.7)	14 (9.3)
Identification of insects and diseases	52 (69.3)	43 (57.3)	80 (53.3)	50 (33.3)
Dose and time of pesticides use	67 (89.3)	57 (76.0)	124 (82.7)	26 (17.3)
Irrigation and water management	3 (4.0)	2 (2.7)	5 (3.3)	145 (96.7)
Harvesting and post harvest handling	9 (12.0)	0 (0.0)	9 (6.0)	141 (94.0)

Figures in parenthesis are in percentage

The data in Table 12 indicated that commercial vegetable farmers mostly used technical information in four areas viz crop varieties selection, dose and techniques of input use, insects and disease identification and use of pesticides to protect vegetable crop. Majority of respondents were use technical information in input use (mostly fertilizers and micronutrient use) followed by crop varieties selection and pesticides use for crop protection from disease and insects. The technical information least used area was irrigation and water management.

3.10.2. Marketing information utilization by respondents

The results of marketing information applied by respondents were presented in table 13 below.

Table 13: Marketing information used by respondents by districts, 2009

Areas of information used	Numbers of respondents		Total	
	Chitwan	Dhading		
	n= 75	n =75	n =150	
	Yes	Yes	Yes	No
Area allocation	17 (22.7)	8 (10.7)	25 (16.7)	125 (83.3)
Crop varieties selection	38 (50.7)	48 (64.0)	86 (57.3)	64 (42.7)
Harvesting time scheduling	29 (38.7)	44 (58.7)	73 (48.7)	77 (51.3)
Post harvest handling	32 (42.7)	9 (12.0)	41 (27.3)	109 (72.7)
Market place selection	15 (20.0)	9 (12.0)	24 (16.0)	126 (84.0)

Figures in parenthesis are in percentage,

Table 13 revealed that farmers mostly used marketing information in crop varieties selection based on market demand followed by harvesting time scheduling. The harvesting time scheduling was done mostly in cucumber, okra, cabbage, and cowpea. The marketing information was least used in vegetable market place selection due to construction of vegetable collection and marketing centers near the vegetable production areas and involvement of vegetable producers cooperatives in local level vegetable market management.

3.10.3. Meteorological information utilization

The results of analysis of meteorological information used by the respondents showed that CV farmers mostly used this information in protecting plant from bad weather (51.3 %) by constructing plastic tunnel or making thatch over the nursery bed. It was mostly done in off season vegetable production such as rainy season tomato production, seedling production of cucurbits, cabbage and cauliflower. Another area of meteorological information used was shifting cropping time (30.0 %).

3.11. Information sharing by respondents

The results of analysis of information sharing data were presented in Table 14 below.

Table 14: Information sharing with other farmers by respondents by districts, 2009

Information types	Chitwan n = 75	Dhading n = 75	Total n = 150	
	Yes	Yes	Yes	No
New varieties of vegetable	40 (53.3)	19 (25.30	59 (39.3)	91 (60.7)
Cultivation practices	46 (61.3)	25 (33.3)	71 (47.3)	79 (52.7)
Insect and disease control technique	44 (58.7)	29 (38.7)	73 (48.7)	77 (51.3)
Dose and technique of fertilizer use	39 (58)	32 (42.7)	71 (47.3)	79 (52.7)
Dose and time of pesticide use	50 (66.7)	31 (41.3)	81 (54.0)	69 (46.0)
Harvesting and post harvest handling technique	14 (18.7)	11 (16.0)	14 (9.3)	136 (90.7)
Market wholesale price of vegetable	40 (53.3)	15 (20.0)	55 (36.7)	95 (63.3)
Market channel and place	10 (13.3)	0 (0.0)	10 (6.7)	140 (93.3)

Figures in parenthesis are in percentage

Table 14 revealed that more respondents were mostly shared four types of information with each other. The mostly shred information was dose and time of pesticide use followed by insect and diseases control technique, cultivation technique, and dose and technique of fertilizer application. The least shared information was market channel and place. This might be due to availability of local level vegetable collection and selling centers to the most of the farmers. Information sharing was more among Chitwan farmers than in Dhading farmers.

3.12. Problems perceived by the respondents in getting and using information

To analyse the influence of problems encounter in getting information from different sources and using information on farmers information seeking and utilization behavior, the respondent were asked about problem they perceived in getting information from different sources (formal, informal and media) and utilizing in CV production and marketing.

3.12.1. Problems perceived in getting information from formal sources

The results of analysis of problems perceived by the respondents while getting information from formal sources showed that difficult to access to formal sources of information (44.0 %) was the major problem followed by lesser competency in JT/JTA (16.7 %) in CV production and difficult to meet extension personnel (8.7 %) due to fewer in number and their workload were the major problems perceived by CV farmers while getting information from formal sources. Accessibility to sources of information was more in Dhading district (73.3 %).

3.12.2. Problems perceived in getting information from informal sources

The results of analysis of problems perceived by respondents in getting information from informal sources indicated that more than half of the respondents (52.1 %) were not perceived any problem. However the information was not reliable (19.5 %) and not complete or enough (18.9 %) were the major problems perceived by more farmers in getting information for CV production from informal sources.

3.12.3. Problems perceived in getting information from mass/group media sources

The problems perceived by farmers while getting information from radio, television, mobile phone, printed material, demonstration, training and exhibition were the most of the farmers mentioned program broadcasting time of farm radio program (69.3 %) and telecasting time of farm television program (48.7 %) was not coincide with their leisure time. Therefore they were not regularly listened farm radio program and watched television program.

In case of mobile user farmers they were facing the problem of network busy and interruption at talking time (32.0 %). Difficulty in getting of printed material (48.0 %) -booklets, leaflets and books, on vegetable cultivation and post harvest value addition was the most important problem perceived by CV farmers to get information from printed material.

In case of information getting from vegetable production demonstration, majority of the respondents mentioned demonstration of scientific techniques for higher production vegetable was not done in their locality (80.6 %) and sometimes such demonstrations were also not need based (15.3 %) of the farmers.

In getting information from training, majority of the CV farmers were not getting training on CV production. Most of the farmers perceived trainings were not available timely (52.0 %) for them.

3.13. Problems perceived by the respondents in efficient use of information

Farmers perceived different problems in the efficient use of technical and marketing information in the actual field. The results of analysis of problems perceived in efficient use of information in CV production showed that the qualitative inputs (seeds and fertilizers) were not available timely (43.6%) and more fluctuating marketing information (37.8%) were the major problems. The marketing information such as wholesale price and quantity to be traded was more fluctuating and creating problem in developing plan for vegetable production and marketing. The concern authority must pay attention to regularize the supply of quality fertilizers and improved seeds to encourage CV farmers to use more technical and marketing information which solve the problems of production potentiality gap and efficient marketing.

3.14. Satisfaction level of respondents in getting information from different sources

In information getting process individual may satisfy if the desired information is easily available timely and not satisfied if he/she faced difficulty in getting information in time. The satisfaction level of CV producers in getting information from different sources was studied and analysed in three levels as satisfied, partially satisfied and dissatisfied respectively. The results of satisfaction level of CV producers showed that majority of the farmers were partially satisfied (71.3%) followed by satisfied (19.3%) and dissatisfied (9.3%) in getting information from the different sources.

3.15. Relation between selected personal characteristics and information seeking and utilization behavior of commercial vegetable farmers

To find out the relation between selected independent variables (personal characteristics viz age, education, ethnicity, gender, family size, farming experience, land used in vegetable cultivation, numbers of vegetable crop grown per year, annual income from vegetables) and study variables information seeking behavior and information utilization behavior of the commercial vegetable farmers, correlation analysis was done. The data regarding relation between selected independent variables and study variables were presented in the Table 15 below.

Table 15: Relation between selected independent variables and study variables

Independent variables	Study variables	
	Information seeking r value	Information utilization r Value
Terrain condition	-0.434**	0.243**
Age	-0.042	-0.011
Family size	0.019	-0.051
Ethnicity	0.173*	0.129
Education	0.263**	0.217**
Farming experience	0.062	0.16*
Area of vegetable cultivation land	0.28**	0.329**
No. of vegetables cultivated per year	0.329**	0.364**
Annual income from vegetable	0.278*	0.435**
Personal facilities of communication	0.468**	0.385**

**Significant at 1 percent level of significance, * Significant at 5 percent level of significance

Table 15 depicted that there was significant positive correlation between information seeking behavior and ethnicity, education, area of vegetable cultivated land, number of vegetable crops grown per year, annual income from vegetable and personal facilities of communication of the respondents. It indicated that the farmer with higher education, allocate more area of land in vegetable cultivation, grow more crops per year, have more annual income from vegetable and have more personal facilities (radio, television, mobile phone, magazine subscriber, vehicle owner) seeks more information for commercial vegetable cultivation. Similarly farmer of Brahamin/Chettri caste seeks more information as compared to janjati, dalit and other caste farmers. It is generally believed that more educated persons are more innovative and more change prone. Therefore the education level affects in the information seeking behavior of farmers. More educated farmers exposed more with different sources of information and their information seeking level is also high. This finding is in line with Gunawardana and Sharma (2007), who reported that more educated farmers' information seeking level was higher on improved farm practices.

The terrain geographical condition has negative relation with information seeking behavior. It means the terrain condition reduces the farmers' information seeking activities and more terrain condition makes the farmers to use only localite sources of information. This finding is supported by Tiwary and Joshi (1993), reported that the difficult terrain in the hilly region of Nepal limited the movement of information seeker and providers so that farmers reliance on localite and cosmopolite personal sources of information.

The age of the respondent has no relation with information seeking behavior of the commercial vegetable farmers. This finding is supported by Gunawardana and Sharma (2007) that the age of the respondent has no effect in their information seeking behavior on improved agricultural practices.

Table 15 revealed that there was significant relationship between information utilization behavior and education, farming experience, total land for vegetable cultivation, numbers of vegetable crops grown per year, annual income from vegetable, personal facilities of communication and numbers of activities done for information seeking. The relation between annual income from vegetable and information utilization was more strong and positive. It seems that more information utilizing farmers could earn more from vegetable farming.

4. Conclusion

The farmers of higher ethnicity, education, more land under vegetable cultivation, higher income from vegetables and have more personal communication facilities seek and utilize more information in commercial vegetable production in Chitwan and Dhading districts. The commercial vegetable farmers mostly sought the information on new varieties, seed quality, fertilizer and micronutrient use, plant protection measures, vegetable wholesale market price and quantity traded in the market. For these information farmers were more relying on local information sources (informal as well as institutional) and give high credibility and preference to those sources (agrovets, neighbours experienced farmers, cooperatives, and electronic media). Farmers' cooperatives were providing more information to farmers in comparison to farmers groups. Information delivery is more effective when farmers' institution and local information sources are strengthen by delivering first hand scientific information to these institutions and sources. The majority of farmers (more than 70 percent) have accessibility to modern information technology especially electronic media and phone which is helping farmers to access the technical and marketing information. The Problems of terrain condition, time constraint, unavailability of information materials and quality inputs were reducing the information seeking and utilization behavior of farmers. To overcome the problems in accessing to information separate type of strategy need to be developed and implemented for information providing in terai and mid hill of Nepal. The women farmers were relying more on men for information on commercial vegetable production. But in information utilization there was no significant difference between men and women. A separate way of information delivery system like use of women groups, training, tours, and demonstration to women is essential to increase their access to first hand scientific information

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Effectiveness of Farmer Field School (FFS) Program in Adoption of IPM Technology in Chitwan District, Nepal

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ABSTRACT

A study was carried out to access the effectiveness of farmer field school (FFS) program in adoption of IPM (Integrated Pest Management) technology among rice growing farmer in Chitwan district of Nepal, out of 13 FFSs conducted in 2004, five FFS were randomly selected, then 12 farmers were randomly selected from each group as study sample. Face to face interview method was used to collect primary information from respondents by using pre-tested semi-structured questionnaire. After participation in IPM FFS majority of farmer were changed their crop production practices. Out of 26 different crop production practices, no changes were found in five different practices. Only few percent (3.33%) of respondents had low adoption rate, more than 50 percent of respondents had high rate of adoption and 40 percent of respondents had medium adoption rate. The average adoption rate was 66 percent. Most of the farmers perceived the FFS a beneficial program for the adoption of IPM technology and the major constraints for adoption was in the technical level. Availability of IPM materials, IPM related training to family members, and agricultural training to respondents were found to be significant factors in IPM technology adoption. So, the extent of adoption of IPM technology can be increased by providing IPM materials to the respondents, and providing IPM related training to farmer's family members. The FFS approach was effective in adoption of IPM technology among farmers.

Key words: Integrated pest management, Farmer Field School, Pests

1 INTRODUCTION

1.1 Background

For decades, the development plans have concentrated more on modernization of agriculture by promoting high external inputs such as chemical fertilizers, herbicides and pesticides. But the agriculture productivity has remained low. There are several factors for low productivity, among them incidence of pest is the major one. The most important aspect of increased production of agricultural commodity is its protection, right from cultivation to its harvesting and storage.

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It has been estimated that annual loss due to pests before and after harvest is about 35-40% (PPD, 1998). Chemical pesticides had been the most preferred means for plant protection in the past. The present trend of the application of pesticide is alarmingly increasing, creating threats on the sustainability of Nepalese agricultural system due to destruction of the natural ecosystem (Joshi, 2001).

Rice is the dominating staple food crop in Nepal. The use of chemical pesticides in rice is high as compared to others crops. It has been reported that about 40-50 percent of the total pesticides used in Nepal was on rice (MOAC, 2005). The excessive use of chemicals to control pests has produced a negative impact on human health and the environment.

Extension approach can play pivotal role in generating as well as disseminating the knowledge among the clienteles. A particular agricultural technology developed so far from the research station needs to be accepted and adopted by the large groups of intended clienteles so as to improve their living standards. So different extension approaches such as training and visit system, farming system research and extension and integrated rural development approaches were developed.

The adverse effect of use of excess chemical pesticide in agriculture gave rise to the concept of Integrated Pest Management (IPM). This concept mainly focuses on environmental education among farming communities to make agriculture system more productive, profitable and sustainable. Since 1995, Plant Protection Directorate (PPD) of Department of Agriculture (DOA) has been practicing IPM as an alternative strategy of pest management. The PDD introduced national IPM program in Nepal in 1997 (PDD,2000). The Government of Nepal has prioritised IPM as an important program and was incorporated in the 9th and 10th periodic plan as well (MOAC,1999). In Nepal, APP (1997-2017) has recognized IPM as one of the priority agenda for sustainable agriculture development.

Similarly, the concepts of FFS was emerged to make the extension efforts more participatory and response to the farmer's need. FFS is the most important approach of IPM where detail observation and presentation of result are performed by the participant farmers. Nepal started FFS approach in 1997 in rice crop with the support of FAO. Since then, more than 18000 farmers have been trained throughout the country (Neupane, 2002). In Chitwan, FFS approach was started in 1997 in rice crop, since then more than 1800 farmers have been trained (DAIU, 2008

1.2 Objectives

Study the effectiveness of Farmer Field School in adoption of Integrated Pest Management technology.

2. Research methodologies

The district consists of 13 farmers groups with 362 participants in FFS training for main season, summer rice in Chitwan districts (DADO, 2004). Out of 13 IPM FFS, five were randomly selected. A total 60 IPM FFS farmers, 12 from each IPM FFS were randomly selected to collect primary information. Data collection was carried out by using pretested semi structured questionnaire. Descriptive and inferential analysis was applied to analysis the data. SPSS and Microsoft excel were used in the data analysis.

3 Conceptual framework for data analysis

3.1. Factors affecting adoption of IPM technology

The adoption of a new technology depends upon different factors such as age, level of education, experience, land holding, nature of farming and participation in trainings, income, knowledge on IPM components, availability of IPM materials, and access with extension worker. A linear regression model was used to know the important factors responsible for adoption of IPM technology,

3.2. Problems and perception analysis

The index was prepared mainly taking into account the qualitative data. On the basis of respondent's frequencies, weighted indexes were calculated for the analysis of constraints to join IPM-FFS and adoption of IPM technology. Farmer's perception towards IPM-FFS and different problems were ranked by using five point scale compromising very important, highly important, normally important, less important and least important by giving weightage on the basis of priority i.e. 5 for the first priority, 4 for the second, 3 for the third, 2 for the fourth and 1 for the fifth priority. Then the priority index for each variable was calculated by dividing weightage average by mean in order to draw valid conclusion and making reasonable decision. The index of importance was computed by using the formula:

$$I_{imp} = \sum \left(\frac{S_i f_i}{N} \right)$$

where, I_{imp} = index of importance

$\sum$ = summation

Si = ith scale value

Fi = frequency of ith importance given by the respondents

N = total number of respondents

3.3 Satisfaction index

Participant's satisfaction level towards the outcome of the IPM-FFS was found out with the help of following scales.

Satisfaction with IPM FFS:

Very high satisfaction = 1.00

High satisfaction = 0.75

Moderate satisfaction = 0.50

Low satisfaction = 0.25

No satisfaction 0.00

$$I = \frac{\Sigma S_i f_i}{N}$$

where, I = index $0 \leq I \geq 1$

S_i = scale value at ith priority

f_i = frequency of the ith priority

N = total number of observations = $\sum f_i$

3.4 Technology adoption

Rate of adoption refers to the full or partial use of recommended IPM technologies by the respondents during the last four years, after receiving the IPM training through FFS. The respondents were asked whether they adopted a particular practice or not, if they adopted they were given a score of 1, if not, they were not given any score. The individual farmer's overall adoption score was calculated by adding response components of IPM technology. The extent of adoption of IPM technology was determined by using the following formula (Ojha, 1999 in Joshi, 2001).

$$\text{Rate of adoption (\%)} = \frac{\text{No. of adopted technology in last four years}}{\text{Total no. of technology recommended by facilitator}} \times 100$$

3.5 Effectiveness Farmer Field School

The effectiveness of FFS was assessed in terms of rate of adoption of IPM technology, change in crop production practices of farmer after participated in FFS, cost, return and net return analysis of IPM participant and IPM non participant plot, and level of knowledge of participant farmer.

4 RESULT AND DISCUSSION

4.1. Respondents characteristics

About 62 percent respondents were male and 38 percent were female with age range from eighteen to seventy five. More respondents (45%) were adult age. The more respondents (48.3%) has secondary level education followed by informal (15%) and intermediate (13.3%) level of education .

4.2 Major sources of income of participant respondents household

The average annual income of respondent's households has been presented in Table 1. The main source of income of most of the respondent was agriculture. The average annual income of respondent was Rs. 35332. Income of respondents from service (Rs. 13,983), business (Rs. 10,766) and remittance were less than that of agriculture. The average annual agriculture income was Rs. 55,916.67

Table1: Average annual income of participant farmers(in Rs.) in Chitwan district

Source of income	Mean	Minimum	Maximum
Agriculture	55916.67	15000	300000
Services	31983	48000	150000
Business	10766	20000	250000
Remittance	36666.66	120000	400000

4.3 Reason of participation in IPM FFS program

The qualitative variables under consideration were quantified using Likert's scaling techniques in five point scales. Then the priority index was calculated to identify the major reason behind participation in IPM FFS programs. Major reason was to gain knowledge about IPM technology (Table 2).

Table 2: Prioritization of thereason behind participation in IPM FFS in Chitwan district (N=60)

	Priority						
Variables	1st	2nd	3rd	4th	5th	Index	Rank
Follow the Tradition	12	10	8	13	17	3.05	III
Suggestion of others	5	3	12	15	25	2.13	VI
To get knowledge on IPM	30	20	5	5	0	4.25	I
To get higher yield	4	8	21	20	7	2.7	IV
To know about FFS	11	28	10	7	4	3.58	II
To grow Pesticide free crop	0	0	30	17	13	2.28	V

4.4 Participation on other Pest management related training

Regarding access to extension worker, majority of the respondents (63.33%) had participated in other pest management related training also (Table 4).

Table 3. Participation on other Pest management related training (N=60)

Past management related other training	Frequency	Percentage
Yes	38	63.33
No	22	36.66
Total	60	100

4.5. Access to extension worker/IPM Facilitator (N=60)

The research results showed that a majority of the respondents (63.33%) had access to extension worker, remaining 36.66 percent had no access to extension services.

4.6. Frequencies to meet with extension worker /IPM Facilitator

Majority (50%) of respondents meet extension worker/ IPM facilitator within a month whereas twenty six percent meet bimonthly followed by occasionally (23.68%).

4.7. Availability of IPM materials

The availability of IPM materials to respondents was not satisfactory. Only 40 percent of respondents received the IPM materials and the rest majority (60 %) were devoid of IPM materials (Table 4).

Table 4. Availability of IPM materials to participant respondents

Availability of IPM materials	Frequency	Percentage
yes	24	40
no	36	60
Total	60	100

4.8. Level of knowledge on IPM technology

The knowledge on IPM technology was assessed by the knowledge of respondents on harmful and beneficial insects.

4.8.1 Knowledge on harmful insect

Fourteen species of harmful insect were recorded in rice field while interviewing the respondents. All the respondents (100%) had knowledge on stem borer and rice gundhi bug. Similarly, majority of respondent (60percent) were familiar with leaf folder, brown plant hoppers, green leaf hoppers, caseworm, mole crickets, and armyworm. But less than 50 percent of respondent had knowledge on grasshoppers, rice gall midge, termites, rice hispa, green bug, and whitefly.

4.8.2 Knowledge on beneficial insect

About 51 percent of respondent farmer were well known about beneficial insect of rice field. Thirteen beneficial insect were recognized by respondents farmer during interview. The majority of respondent (>90 %) were well known about spider and dragon fly. Similarly, tiger beetle, and wasp as beneficial insects were known by 62 percent and 52 percent of respondents. Other insects were recognized by less than 50 percent of respondents.

4.9 Adoption of technology

4.9.1 Change in crop production practices of participants farmers (n=60)

The findings showed that changes in crop production practices were found among responding farmers after participation in IPM FFS (n=60). It was found that there was no change in adoption of some practices like variety selection, weeding, use of organic manure, management of irrigation and planting date management before and after participation. The frequency of farmers adopting the practices like selection of resistant variety, soil treatment, cutting the plant at the time of harvest, use of light trap, use of botanical pesticide, removal of infected plants, use of well decomposed manure, use of balanced fertilizer, application of fertilizer in split dose, pest monitoring, keeping the bund clean, management of appropriate distance, seed treatment, summer ploughing was found to be increased. Some production practices like no application of nitogen fertilizer when insect attack is high, no use of pesticide when there were more numbers of beneficial insects, use of selective pesticide, cutting the tip of plants, use of chemical pesticide according to nature of damage and firing of infected plant residue were practiced by farmer only after participation in IPM FFS.

Table 5: Change in crop production practices by IPM participant respondents, 2008.

Crop production practices	Frequencies		Percentages	
	Before	After	Before	After
Selection of variety	60	60	100	100
Selection of resistance variety	12	31	20	51.66
Soil treatment with lime	2	33	3.33	55
Soil treatment chemicals	14	41	22.21	68.33
Summer ploughing	32	49	53.28	81.66
Use of organic manure	60	60	100	100
Use of well decompose organic manure	51	57	85	95
Use of balance fertilizer	20	48	33.33	80
Application of fertilizer in split dose	14	45	22.21	75
Pest monitoring	27	59	45	98.33
Not application of N fertilizer when insect attack is high	0	34	0	56.66
Keeping bund clean	41	51	68.33	85
Management of appropriate distance	21	33	35	55
Management of irrigation	56	56	93.33	93.33
Seed treatment	17	45	29.84	75
Cutting the plant at the ground level burning harvesting	33	41	55	68.33
Planting date management	59	59	98.33	98.33
Weeding the crop	60	60	100	100
No use of pesticide when there is enough beneficial insect	0	39	0	65
Use of selective pesticide	0	25	0	41.66
Use of light trap	7	20	11.66	33.33
Cutting the tip of plant	0	7	0	11.66
Use of botanical pesticide	8	25	13.32	41.66
Use of chemical pesticide according to nature of damage	0	33	0	55
Removal of infected plant	27	53	45	88.33
Firing of infected plant residue	0	35	0	58.33

4.9.2. Rate of adoption of IPM technology by participant farmers

The technology adoption can be determined by determining the rate of adoption of twenty one major components of IPM technology recommended in the study area. The study showed that the 57 percent of respondents were having high level of adoption, 40 percent had medium level of adoption and 3 percent had low rate of adoption (Table 6) . This clearly indicated that the rate of adoption in study area was satisfactory.

Table 6: Rate of adoption of participant farmers

Categories	Frequencies	Percentages
Low (<34%)	2	3.33
Medium(34-66)%	24	40
High(>66%)	34	56.66
Total	60	100

4.10. Causes of unsustainability of IPM

The qualitative variables under consideration were quantified using Likert's scaling techniques in 3 point scales. Then priority index was calculated to identify the major causes of unsustainability of IPM technology. It was found that late response of IPM technology to manage the insets was major cause of un-sustainability (Table 7).

Table 7: Prioritization of the causes of un-sustainability of IPM.

Variables	Priority				
	1st	2nd	3rd	Index	Rank
Late response	42	18	0	2.7	I
Labor intensive	20	27	13	2.12	III
No application when there is more insect	27	22	11	2.27	II
Costly	10	19	31	1.65	VI
Need regular supervision	9	20	31	1.63	VII
Lack of IPM tools	18	25	17	2.02	IV
Lack of technical support	12	33	15	1.95	V
Not cover the large area	2	21	37	1.42	VIII
Not adopted in community	0	25	35	1.42	VIII

4.11 Satisfaction with IPM FFS program

The value of satisfaction index indicates that the farmers were satisfied with FFS program, their satisfaction inclined towards highly satisfaction.

Table 8: satisfaction with IPM FFS

Satisfaction level	frequencies	Scale value	Scale score	Index
Very highly	8	1	8	0.620
Highly	21	0.75	15.75	
Moderately	26	0.5	13	
Little bit	2	0.25	0.5	
No satisfied	3	0	0	
Total	100		37.25	

4.12. Constraints associated with adoption of IPM technology

The priority index was calculated to identify the constraints associated with FFS generated IPM technology adoption. Farmers considered the major constraint was associated with technical level (Table 9). Unqualified technicians, lack of technical support to farmers, non availability of IPM tools were major technical constraints.

Table 9: Prioritization of the constraints associated with adoption IPM technology.

Variables	Priority			Index	Rank
	1st	2nd	3rd		
Policy level	32	13	15	2.28	II
Farm level	0	14	46	1.18	IV
Community level	6	11	43	1.38	III
Technical level	29	21	10	2.31	I

4.13. Factor affecting the adoption of IPM technology.

To estimate the quantitative relationship between independent variables and rate of adoption, a multiple regression model was used. For this purpose age, year of schooling, access to extension worker in last year, agriculture training to respondents, IPM related training to family member, total agriculture income, average knowledge level of respondents on IPM elements, and availability of IPM materials were taken as independent variables.

Table 10: Factors affecting adoption of IPM technology

Variables	Coefficient	Std. error	P-value
Constant	58.356	9.922	.000
Age of respondent	-0.179	.133	.186
Level of education respondent	-0.151	.430	0.727
Total agriculture income	0.037	0.031	0.240
Access to extension worker	-0.163	0.134	0.232
Pest management related training to respondent	7.826	3.449	0.028**
IPM related training to family member of respondent	16.619	4.377	0.000*
Average knowledge of respondent on IPM element	14.079	11.030	0.208
Availability of IPM materials	9.270	3.664	0.015**

*Multiple r= .706 R=0.497 Adjusted R= 0.417 F=6.286***

Significant at 0.01 level of significance Significant at 0.05 level of significance*

Out of the eight independent variables only three were found to have been affecting the adoption of IPM technologies significantly (Table 10). The study indicated that the availability of IPM materials, pest management related training to respondents and IPM related training to family members were significantly and positively associated with the adoption of IPM technologies. Other factors did not affect adoption of IPM technology.

5. Conclusion

A moderate level of knowledge regarding the harmful and beneficial insect was found in majority of respondents. The extent of adoption of IPM technology was high (50 % of the respondents). The study showed that about 57 percent of the respondents were having high level of adoption, 40 percent had medium level of adoption and 3 percent had low rate of adoption. This clearly indicated that the rate of adoption in study area was satisfactory. Varying changes were found in crop production practices among respondents after participation in FFS. Major causes for the un-sustainability of IPM technology as pointed out by the respondents were: late response, inapplicable in case of widely spread of pest, require more household materials and skill, unavailability of IPM tools, lack of technical support, costly, need regular supervision, not coverage of large area and not adopted in community. Technical constraint was the main constraint associated with FFS generated technology adoption. Availability of IPM materials, agriculture training to farmer, and IPM related training to family members of respondents were significantly associated with technology adoption. Hence IPM related material and pest management related training (IPM refresher training) should be regularly provided to farmers.

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Marketing chain developments in ginger (*Zingiberofficinale* Rosc. of the *Zingiberaceae* family): A case from Western Region Nepal

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Abstract

A study was conducted to analyse the marketing chain development in ginger produced in Palpa, Gulmi, Nawalpari and Rupandehi district of western region. A total of 30 traders, involving in collection, processing, wholesale marketing and export of ginger were randomly selected from the list prepared by District Agriculture Development Office (DADO). Eighty percent traders buy ginger from the same district and only fourty five percent traders brought to export market. Price fixation was dominated by exporter and Indian market. In the study areas traders responded that 54 percent price was controlled by Indian market and while 33 percent was controlled by the exporter and local market contributed only 13 percent. Problems of export are the quality of the product and price. Nepalese ginger lacks cleanliness that is why price remains at lower level. From the problem ranking on marketing, it was found that lack of grading and cleaning and drying practice was the most problematic on marketing. Other two most problems was lack of storage facility and processing plant . From the study it was concluded that to make ginger marketing more profitable and reliable concerned agencies should focus their programs on product standardization and diversification.

Key words: market chain, ginger, export

1. Introduction

Nepalese economy is Agriculture based. Country's 66 percent active population is dependent on this sector and contributed 34.14 percent of national GDP (ABPSD 2014). Ginger is the main agro based export commodity of Nepal. It has estimation that in Nepal, there are almost 66,000 families involved in ginger cultivation (GoN, 2012). 23941 metric ton of fresh and dried ginger of worth NRs 500 million was exported (MOAD 2013). But its share to the world market is in smaller amount. Smallholder farmers mainly carry out ginger farming which has medium impact on export potential and

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socioeconomic sector. Major production of Nepalese ginger goes to the Indian markets. Production processing and trade flows of ginger to India is mainly from Jhapa, Morang, Parsa, Rupendehi, and Banke district.

Market for Nepalese ginger is insecure. Price varies according to global production. When there is no demand of ginger in India then no market in Nepal. Traders control the farm gate price. Producer has no effective marketing strategies. As ginger crop need high-input use, the high cost of production could result in loss if market prices run through irregularities and instabilities (Gita &Kifle, 2011). In such situation producer must keep caution. Generally it is seen that when receive good price of ginger in one year, area is increased for next year and vice versa. Such cyclic pattern of price rise and fall is prevailing due to demand and supply interaction and time lag on production plan decision.

In terms of the total export volume, Nepal is the third largest ginger exporting country. But for total earnings from export it is 10th position (FAO, 2014). It is because of lowest unit price of Nepalese ginger among major exporting countries. Therefor the study was under taken with the aim of knowing marketing pattern, problems and marketing chain development for its sustainability.

2. Research Methodology

This study was conducted in Palpa, Gulmi, Nawalparsi and Rupandehi distirct. A total of 30 traders, involving in collection, processing, wholesale marketing and export of ginger were randomly selected from list of four districts. Field investigators under the direct supervision of the researcher collected field level cross section data. Data analysis done with the help of statistical package for social sciences (SPSS) and Micro soft office excel. Results obtained on involvement of traders on transaction, price fixation and problems of export.

Problem ranking of Trader's perception to the different problems of ginger marketing was ranked by using five point scales. Weightage is given on the basis of priority i.e. 1 for most serious and 5 for least one. Weight established was 1.5 for rank first, 1.25 for second and like this for fifth rank weights given was 0.5. Then the indexes of importance for the problems were calculated in order to draw valid conclusion and making reasonable decision. The index of importance was computed by using the formula:

$$I_{imp} = \sum \left(\frac{S_i f_i}{N} \right)$$

where,

I_{imp} =Iindex of importance

$\sum$ = Summation

S_i=ith scale value (i = 1.5, 1.25,……,0.5)

f_i= Frequency of ith importance given by the respondents

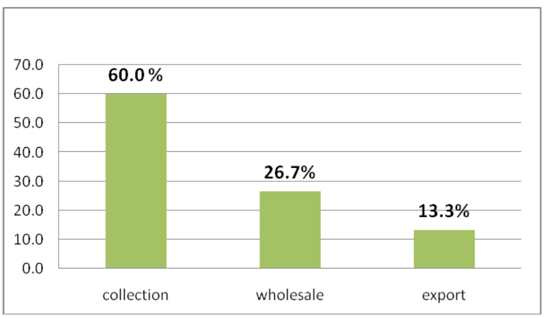
N = total number of respondents

To rank the problems faced by the traders, five different problem statements were taken into consideration. These problems were namely on grading and cleaning, processing, storage, price fluctuation and market information.

Results and discussion

Traders' category in the ginger market

In the study areas three categories of traders were found. Among them 60 percent were involved in the collection (Fig 1). Likewise wholesalers in the market were 26.7 percent. But the size of exporter in the market was only 13.3 percent.

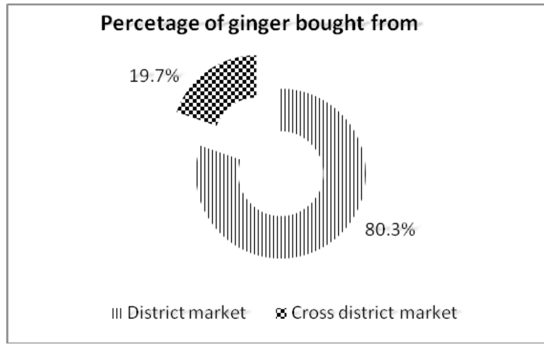


Source: Field Survey, 2012

Fig 1:Traders' categories in the ginger marketing

3.2 Ginger buying pattern

In the study areas ginger buying pattern assessed on the basis of buying the ginger within the district and cross district. The ginger traders purchased 80.3 percent of the product from within the district market. Remaining 19.7 percent was from the cross district market. Small traders mainly purchased gingers in the district market. Large trader mainly brought their product from cross district market (Fig 2).

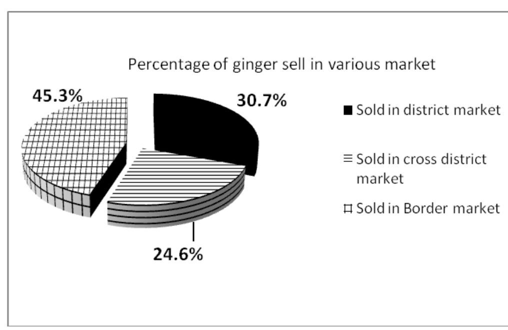


Source: Field Survey, 2012

Fig 2: Buying pattern of ginger by ginger traders

3.3 Ginger sale pattern

Sales pattern of ginger in the study areas appears in three categories. Those marketswere district market, cross district market and border market. Among the total sales, 30.7 percent ginger was sold in the same district. Traders themselves brought to export market was 45.3 percent, and remaining 24 percent ginger was sold to the other district markets by traders (fig 3).

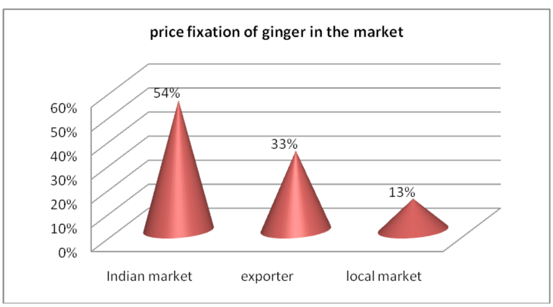


Source: Field Survey, 2012

Fig 3: Selling pattern of ginger by traders

3.4 Price fixation

Major share of traded ginger goes to India that is why price is mainly dependent on Indian market price. Demand and supply situation is unpredictable before production plan. Commission agent and local trader do not take risk of price. There is no contract farming and buy back guaranty of the product. Whole seller or exporters see the market signal on Indian market and price is controlled according to the situation. In the studies 54 percent traders responded that price was fixed by Indian market (Fig 4). While 33 percent traders believed, it was fixed by exporter. Only 13 percent responded price of gingerwas fixed locally.



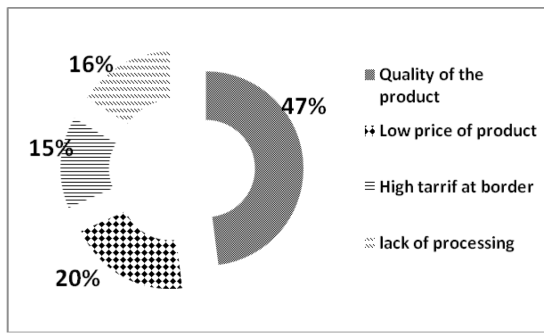
Source: Field Survey, 2012

Fig 4: Prices of ginger fixation in the market

3.5 Problems in ginger export

While exporting ginger they are facing problems at border issuing the quality standard of the product. Intermittently technical barriers were created by Indian government showing the issue of sanitary and phyto-sanitary provision. Nepalese government has also set the quality standard for fresh and dried ginger

In the study areas 47 percent traders responded that quality of the product was the major problems for export (Fig 5). Nepalese ginger fetching very low price in the world market. Nepal is world's 3rd largest in production but in trade value it is 10th in rank. It is because of poor quality of product.Twenty Percent traders responded that they were facing problems of low price of product while exporting. Other problems faced by traders while exporting ginger was high tariff at border and lack of processing facility at border.



Source: Field Survey, 2012

Fig 5: Problem of ginger export

3.6 Problems ranking for ginger marketing

Traders are facing several market related problems. Among them most important five problems of marketing were taken for analysis and scaling was done on the basis of severity which was from 1.5 for the most problematic and 0.5 for the least one. In the study areas lack of grading and cleaning practice was the top most problems. Lack of storage facility and processing practices were felt as 2nd and 3rd most important problems followed by price fluctuation and lack of market information (Table 1).

Table 1. Problems ranking on ginger marketing

Problem	Weights	Rank
Lack of grading and cleaning practice	39.75	I
Lack of processing practices	30.5	III
Lack of storage facility	34.5	II
Problem of price fluctuation	26.5	IV
Lack of market information	19	V

Source: Field Survey, 2012

3.7 Market chain map of ginger

Market chain map of ginger in western Nepal is presented here on the basis of study of the research areas (Figure 6). Market chain helps us to know how the product flows from production to the consumption points. During the process different function and enablers act according to their role. In the study areas there were 60 percent road head traders, 26.7 percent wholesaler, and 13.3 percent exporter. Road head traders and cooperatives collected directly from famer and supply to wholesaler and exporter. Among the collected ginger, 30.7 percent was sold on same district, 24 percent to other district and 45.3 percent to export market.

4. Conclusion

Nepal is producing and exporting remarkable amount of ginger in the country. Due to less efficient marketing chain development Nepalese ginger is not getting significant benefit from world market. Different actors and enablers have to improve the situation. Major role for price fixation was playing by exporter and Indian market. Lack of cleaning and grading practice was major problems for ginger marketing. While in exporting ginger most affecting problem was the quality of the products creating optional technical barriers. So to get better price from export of ginger market chain management, proper strategies for product standardization, product diversification and price controlling mechanism should be developed.

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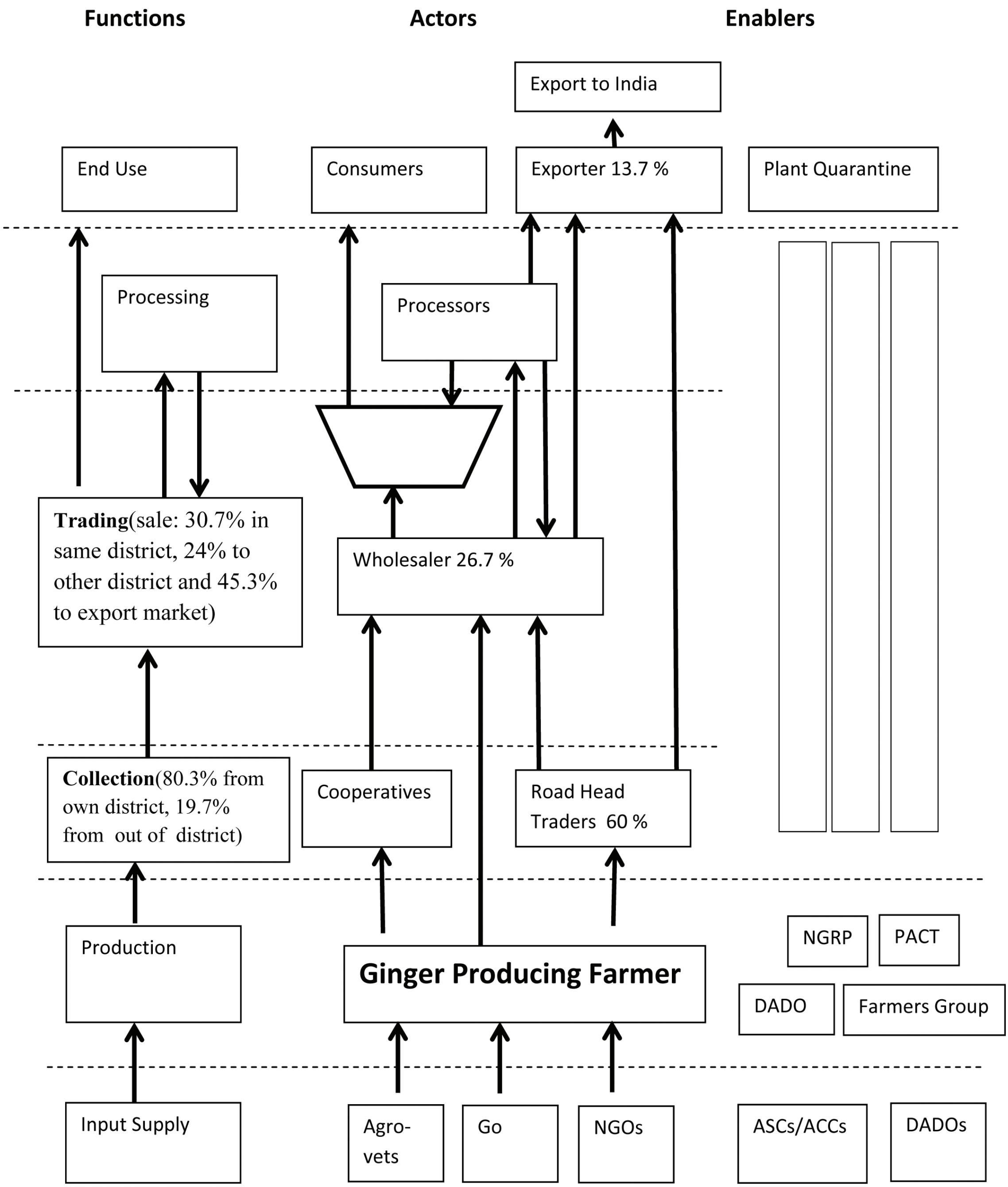
Figure 6: Marketing chain development of ginger: A case of western development region of Nepal



Analysis of Marketing Practices of Apple in Mustang District of Nepal

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Abstract

Apple is one of the most economically viable fruit of the high-hills since it has great export potentiality in the international market. Apple is one of the key fruits with potential to generate income and employment in the high mountain districts of western Nepal. Despite this fact farmers are unable to get proper price even in domestic market. The study analysed the marketing practices of apple in mustang district using simple random sampling of 80 farmers from two village development committee (VDC) namely Kobang and Tukuche, comprising 40 samples from each study VDC. The survey was conducted in 2009. For the market information, two contractors each from Kobang and Tukuche VDC, two wholesalers and two retailers each from Jomsom, Beni, Baglung and Pokhara were interviewed. Data obtained from semi-structured questionnaire were subjected to descriptive analysis. The results showed that pre-harvest contractual system was the most common mode of selling and Jomsom, Beni, Baglung and Pokhara were the major market spots for apple. The marketing margin per kg was higher in Kobang (Rs 30.39) while producers' share was higher in Tukuche VDC (Rs 34.04). Most of the traders perceived that lack of transportation facilities and market information were the major problems in marketing of apple in the study area.

Key words: marketing, pre-harvest contract, marketing margin, producer's share

1. Introduction

Apple is one of the key fruits with potential to generate income and employment in the high mountain districts of western Nepal. Apple is a prominent and one of the important prioritized high value crops (APP, 1995). Apple is a main temperate fruit of Nepal, which is cultivated in 5,674 hectares with production of 48,946 mt and productivity 8.63 mt/ha. It contributes about 4.75 percent of the total fruit production and occupies 5.6 percent of the total fruit area in Nepal (MOAC, 2012). Largest productive area under apple is found in Jumla (2472 ha), followed by Kalikot (1084 ha), Mugu (818), Mustang (708 ha) and Solukhumbu (414 ha) (MOAD, 2012). Most of the apple growing districts are not well linked with black topped roads. They are not easily accessible to the national and export marketing channels, although air transport service has contributed a great extent to transport these apples at the urban market centers of Nepal. The construction

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of agricultural roads to these commercial production pockets, envisaged by APP, will link these districts to roadways and develop opportunities for exporting Nepalese delicious apples to neighboring countries (MDD, 2000).

The most common and widely used marketing system in the hills of Nepal is the contractual system (Shrestha et al., 1998). Farmers make contractual agreements with traders just few months prior to the harvesting of fruits (Shah, 1992; Tomiyashu et al., 1998). Pre-harvest contract could be profitable than self marketing due to product diversification into different markets and volume of the product sold (Subramanyam, 1981). Mainly the contract was done before ripening of fruits and the basis of price fixation was the amount, quality of fruit, variety, demand and supply situation. In non-contractual system most of the producers sells their product direct to the wholesalers.

Moreover, due to continuous increase in the cost of production, harvesting, carrying and freight charges, the small producers are not getting a fair return from the marketed fruits. All these difficulties in the process of production, harvesting and marketing of fruits affect farm income as well as limit the expansion of agricultural enterprises. The agriculture needs diversification and commercialization to raise the income and employment opportunities of the farmers by identifying high value low volume crops, which have comparative advantage, such as fruits and vegetables, and by optimally utilizing the available resources for production and marketing operations for sustainable development (Gautam and Saraf, 1995). Thus, realizing importance of marketing of apple to increase farm income, this study explores the present marketing systems and channel of apple marketing and assesses the major problems faced by apple traders. So this study may also helpful for the formulation and implementation of plans and programs for the concerned stakeholders within the district.

2. Research Methodology

Mustang district was purposively selected for the purpose of the study based on the relatively higher area coverage by apple. Kobang and Tukuche VDCs were purposively selected on the basis of higher area coverage of apple cultivation. The required data for this study were collected through survey method from a sample of 80 farmers (which covers more than 30 percent of apple grower) from Kobang and Tukuche VDC of Mustang district. For the market information two contractors from each VDC were selected. Similarly, two wholesalers and two retailers were selected each from Jomsom, Beni, Baglung and Pokhara. Due to limited resources, complete listing and enumeration of apple growers in study areas was not possible. 80 farmers were randomly selected taking 40 from each study VDC. The secondary data were collected from the various publications of related organizations like Fruit Development Directorate (FDD), Market Development Directorate (MDD), Ministry of Agricultural Development (MOAD), Agro-Enterprise Center (AEC), Central Bureau of Statistics (CBS), and District Agriculture Development Office

(DADO), Mustang.

2.1 Methods of data analysis

Marketing margin and producer's share

Marketing margin is the difference between the net price received by the farmer and the price paid by the consumer. This was calculated by subtracting the farm gate price from the retail price.

Marketing margin = Retailer price (Pr) – Farm-gate price (Pf)

Similarly, producer's share is the price received by the farmer expressed as a percentage of the retail price that is price paid by the consumer

Ps = Pf/Pr X100.

Indexing

Traders perception on the importance given to the different marketing constraints were analyzed by using three point scale of constraint comprising very high importance, medium importance, and the least importance by assigning scale value as 3, 2, and 1, respectively. The index of importance was computed by using the following formula:

$I_{imp} = \sum (Si\ F_i /N)$

Where,

I_{imp} = Index of importance

$\sum$ = Summation

Si = Scale value

F_i = Frequency of importance given by the respondents

N = Total numbers of respondents

3. Result and Discussion

3.1. Factors determining the price of apple

Various factors that determined the price of apple in the study area were explored. Altogether, six different factors were identified by the apple producers and were asked to assign scores to identify the major factor. The most important factor that determined the price of apple producers in both VDCs was the quality of apple produced (Table 1).

Table 1. The factors determining the price of apple in the study area (2008)

Factors	VDCs			
	Kobang		Tukuche	
	Index	Rank	Index	Rank
Quality of fruits	2.775	I	2.675	I
Size of fruits	2.550	II	2.150	III
Apple variety	2.200	III	2.475	II
Time of harvesting	2.000	IV	2.100	IV
Age of orchard	1.825	V	1.900	V
Last year market price	1.500	VI	1.550	VI

Table 1 showed that in Kobang VDC, quality and size of fruits got the highest rank, followed by apple variety and time of harvesting where as in Tukuche VDC quality of fruits and apple variety got the highest rank followed by size of fruits and time of harvesting. Similarly, age of orchard and last year market price was other important factors that determined the price of apple.

3.2. Grading practice

Grading is done according to size and shape of fruits. Respondents were asked whether they did grading of apple on the basis of size and shape of apple and determine the price before selling.

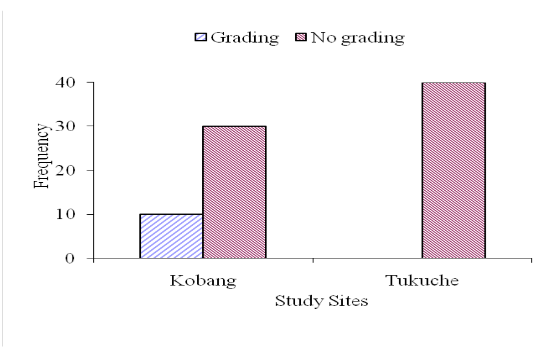

Figure 1. Grading practice of apple in the study area (2008)

The figure 1 showed that the grading practice of apple in the study area only few respondents (10 percent) from Kobang VDC performed grading practice whereas none of the respondents from Tukuche VDC did grading. No grading practice was more common in Tukuche VDC as compared to Kobang which might be due to higher quality of apple produced in Tukuche VDC followed by high contractual system of selling (Table 2).

Due to the lack of knowledge and marketing skills, farmers rarely practice any grading. They packed fruits of all shapes and sizes in beer carton and carried these to markets. As transport cost was high (including the opportunity cost of family labour), non grading practice resulted higher transportation cost compared with a grading practice where only higher quality fruits were transported to distant markets where price was better, at the same time selling lower quality fruits in nearby markets with lower price. In other words, there is a need for promoting a sales strategy based on the concept of price discrimination.

3.3. Marketing system and marketing channels of apple

Marketing of apple encompasses all the activities being performed in moving apple from producers to the hands of ultimate consumers. Marketing system creates time, space and form utilities of the farm product for the producers, the traders and the consumers. The producers, traders, transporters, wholesalers, retailers were the main actors of apple marketing in Nepal.

Apples for Kathmandu and other major urban markets are mainly supplied through imports from China and India. The domestic product contributing negligible amounts, although apples produced in Mustang and Jumla are starting to sell with branding.

Mainly the fruit was hand picked, collected in the heap, packed in cartons and transported via bus, mule or by plane.

Few of the growers sold the product to the Jomsom market by themselves. Hand picking method was the most common mode of harvesting. The common marketing channel of the Kobang and Tukuche are presented in Figure 2.

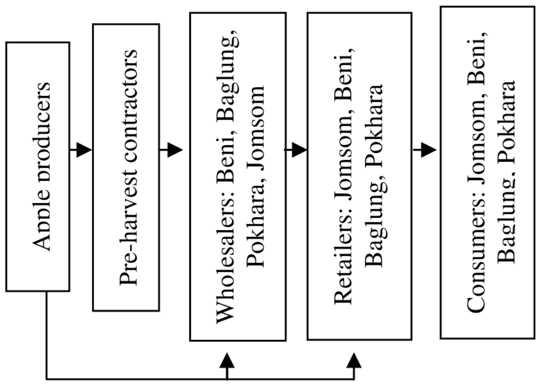

Figure 2. Marketing channels and functionaries in the marketing of apple produced in Kobang and Tukuche VDCs

3.4 Mode of selling

Generally, two types of selling were practiced in the surveyed area i.e. selling to the wholesaler/collector and pre-harvest contractors were followed by the farmers of the respective VDCs (Table 2). The pre-harvest contract system was the most commonly preferred system of selling. Majority of the respondent (55 %) were practiced the pre-harvest contract system of selling compared to non-contract system of selling (45 %) Farmers preferred pre-harvest contract system because of the low risk associated as well as easy way of getting money without harvesting and transportation burden.

Table 2. Selling practice of apple in the study area (2008)

VDCs	Mode of selling		Total
	Contract system	Non-contract system	
Kobang (n=40)	14 (35.0)	26 (65.0)	40 (100.0)
Tukuche (n=40)	30 (75.0)	10 (25.0)	40 (100.0)
Total (N=80)	44 (55.0)	36 (45.0)	80 (100.0)

Figures in parenthesis indicate percent

Table 2 indicated that the pre-harvest contract selling was more common in Tukuche where 75 percent of the apple growers sell their product according to pre harvest contract system as compared to Kobang VDC (35 %), which might be due to the higher quantity of apple produced in the Tukuche compared to Kobang. While the numbers of respondents following non-contractual system of marketing were more in Kobang VDC because of the low volume of production than Tukuche VDC. Mostly direct selling to the wholesalers was the most common pattern of selling in non-contractual system.

3.5 Marketing margin and producer's share

From the study, it was found that average farm gate price (NRs/kg) of apple was Rs 14.04 in Kobang and Rs 15.13 in Tukuche while Rs 14.58 was the average of the two VDC. Average retail price was found Rs 44.43 per kg of apple. So overall marketing margin of the study area was found Rs 29.85 whereas the producers' share was 32.8 percent. The marketing margin per kg was higher in Kobang (Rs 30.39). The higher marketing margin might be due to the lack of market price information among the farmers of Kobang VDC as compared with Tukuche (Rs 29.30). The producers' share was higher in Tukuche (Rs 34.04) indicating higher marketing efficiency as compared to Kobang (Rs 31.60). In developing countries like Nepal, marketing services are costly due to very poor transportation infrastructure and marketing margins tends to be high (Bastakoti, 2001). This was highly affected by the accessibility condition of production sites. Generally, high marketing margin was linked with exploitation by the middlemen. The marketing margin was shown in Table 3.

Table 3. Marketing margin and producers' share by VDC (2008)

Particular	VDCs		Total
	Kobang	Tukuche	
Average farm gate price (NRs/kg)	14.04	15.13	14.58
Average retail price (NRs/kg)	44.43	44.43	44.43
Marketing margin (NRs/kg)	30.39	29.30	29.85
Producers share (%)	31.60	34.04	32.82

3.6 Marketing problems

Marketing plays important role for the easy disposal of the product from producer ultimately to the consumer. Due to low storage life in ordinary condition, easy and safe disposal of the commodity after harvesting is imperative.

Various problems were mentioned and assigned scores by the apple traders. Study showed that the major marketing problems as perceived by traders were the problem of lack of transportation facility from the production to consumption zone followed by lack of market information (Table 4). The third rated problem was perishability of product followed by lack of packaging materials and lack of processing facility. Similarly, price instability and lack of storage facility were other serious problems being faced by traders on apple marketing.

Table 4. Intensity of marketing problems faced by apple traders (2008)

Problems	Index	Rank
Lack of transportation facility	2.775	I
Lack of market information	2.575	II
Perishability of product	2.425	III
Lack of packaging materials	2.100	IV
Lack of processing facility	2.050	V
Price instability	1.825	VI
Lack of storage facility	1.775	VII

4. Conclusion

Kobang and Tukuche are the potential production areas of apple due to climatic and edaphic suitability. The marketing systems were not well developed. There are several areas for improvement like transport facility, market price information, packaging, storage, and grading to fetch good price by apple producers. The contractual system was the most common mode of selling. Apple growers were facing several marketing problems. For getting adequate benefit it is better to practice co-operatives or self-marketing. Hence, well developed market structures equipped with good storage and processing facilities should be provided for the promotion of apple marketing.

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A Study on Impact of Agricultural Inputs on Agricultural Productivity

S. Karki, V. P. Mehta, and Y. Padhyoti

ABSTRACT

A study was conducted to study the impact of availability of agricultural inputs in agricultural productivity improvement. The study was based on secondary data of twenty years (1988 to 2008) of agricultural inputs supply in Harayana of India. The results of the study revealed that use of all agricultural inputs viz. irrigation, area under HYV, fertilizers, tubewells and pumpsets, credit, tractors and budget on agriculture by government had increased during the study period. The use of pesticide however had decreased over the years. When we take the area under major crops into consideration the area under rice, wheat, total cereals, total foodgrains, oilseeds, sugarcane and cotton had increased while that of jowar, bajra, maize, barley, gram and pulses had decreased. The growth rates in terms of yield were positive for most of the crops except for jowar, gram and oilseeds. Crops viz. rice, wheat, bajra, total cereals, , oilseeds, sugarcane and cotton have positive growth in production but crops jowar, barley, gram and pulses had negative growth. The Cobb- Douglas type of analysis shows the significant impact was only tubewells and pumpsets on AGDP and the impact was positive.

Keywords: Growth rates, inputs, Agricultural GDP

1. INTRODUCTION

Inputs are crucial factors of production in modern agriculture. It is almost impossible and irrational to produce agricultural commodities without inputs. Eminent economist V. S. Vyas (2006) notes, 'additions to the output have been realized by increase in yield per hectare rather than by an expansion of cultivated area, latter has remained more or less constant'. He also added that the increase in output through yield is achieved by intensive agriculture which requires not only better access to non-land inputs but also a much more careful use of these inputs. Regarding the importance of input, N. E. Borlang has said, 'If the HYV were the catalyst that ignited the green revolution, the chemical fertilizers were the fuel that powered the forward thrust'. The importance of input HYV was also highlighted in the statement of E. Evenson and D. Gollinn (2003) 'Over the period 1960 to 2000, international agricultural research centres, in collaboration with national research programmes, contributed to the developments of "modern varieties" for many crops. These varieties have contributed to large increase in crop production'. 'Yield per unit time and land has increased markedly during the past 30 years in the four major cropping systems, where wheat, rice and maize were grown, a result of intensified crop management involving improved germplasm, greater inputs of fertilizer, production of two or more crops per year on the same piece of land, and irrigation' (Cassman, 1999). 'Intensification of agriculture by use of high yielding crop varieties, fertilization, irrigation and pesticides have contributed substantially to the tremendous increase in food production over the past fifty years' Matson *et al*.(1997).

Haryana along with Punjab is regarded as grain bowl of India and one of the high input user states. The government of Haryana since inception of the state has given due importance to agriculture and has also made arrangements for proper availability and use of agricultural inputs. This effort of the government should be assessed for future plans on agriculture and strategy to increase production to feed the growing population. So this study was carried out to observe the trends in input use, in area, production and yield of major crops and the impact of inputs on agricultural GDP.

2. METHODOLOGY

The present study was based on secondary data for the period 1988-89 to 2007-08. The data were collected from various issues of Statistical Abstracts of Haryana, published by the Department of Economics and Statistical Organization, Government of Haryana, Chandigarh. The study period was divided into three periods, period-I of first ten years from 1988-89 to 1997-98, period-II of later ten years from 1998-99 to 2007-08 and an overall period of twenty years. The trends was observed by calculating compound growth rates and the impact of inputs on agricultural GDP was found by regression analysis using Cobb-Douglas type of production function.

Compound Growth Rate

To work out the compound growth the log-linear/ Cobb-Douglas type of function in the following form was fitted.

$Y = a\, b^{t}$

The log form of the equation is:

$$\mathrm{Log}\,(y) = \mathrm{Log}\,(a) + t\,\mathrm{Log}\,(b)$$

Where, Y= Variable for which the growth rates are calculated

a = Constant

b = Regression coefficient

t = Time variable in years

The CGR in terms of percentage was obtained by using the following formula

CGR= [antilog (b)-1]*100

Cobb-Douglas Regression Analysis

$$Y = \alpha X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5} X_6^{\beta_6} X_7^{\beta_7} X_8^{\beta_8}$$

Where, Y = Agricultural gross domestic product (Rs. Crore)

X_1 = Gross area under irrigation (000 ha.)

X_2 = Total area under HYV

X_3 = Fertilizer consumption

X_4 = Pesticides consumption (Tones)

X_5 = No. of tube wells and pump sets

X_6 = Cooperative credit (lakh Rs.)

X_7 = No. of tractors

X_8 = Allocation of budget on agriculture by Haryana government (Lakh Rs.)

3. RESULTS AND DISCUSSION

3.1. Growth rates of agricultural inputs

The trend in use of agricultural inputs in the state was depicted by the growth rates in table 1. The significant positive value of the growth rates showed that the use of agricultural inputs had increased over the years. Gross irrigated area in the state had increased by 1.63 percent in the overall twenty years and it may be attributed to increase in number of tubewells and pumpsets, effective irrigation system in the state etc. The area under High Yielding Varieties (HYV) also increased for rice, wheat and bajra. The overall annual growth for these crops was 3.87 percent for rice, 1.70 percent for wheat and 2.17 for bajra. The use of chemical fertilizers and N, P, K nutrient fertilizers had shown a positive growth of 4.57, 4.52, 4.41 and 24.81 percent respectively and it was due to increased use of high yielding variety, irrigation facility and commercialization of agriculture. The introduction of insect-pest resistance variety and growing health consciousness of consumers had decreased the use of pesticides by 0.54 percent. Number of tubewells and pumpsets and tractors were increased by 1.71, 4.87 percent respectively and this increment due to the easy loan systems adopted by various banks. The modernization of agriculture with greater use of inputs brought positive growth in the credit disbursed by Primary Agricultural Credit Societies by 18.69 percent. The budget allocated by Haryana government in agriculture sector increased by 10.49 percent over the years.

Table: 1. Compound Growth Rates of Different Agricultural Inputs (Percent/annum)

S.No.	Agricultural inputs	Growth rates in the period		
		Period -I (1988-89 to 1997-98)	Period -II (1998-99 to 2007-08)	Overall Period (1988-89 to 2007-08)
1.	Gross irrigated area (000 ha)	1.85**	0.89**	1.63**
2.	Area under High yielding variety (000ha)			
	Rice	3.19*	2.79**	3.87**
	Maize	-4.71**	-2.51*	-4.31**
	Bajra	-2.97*	1.86*	2.17**
	Wheat	1.19**	0.86*	1.70**
	Total	0.87*	1.38**	2.13**

3.	Fertilizers use (Tonnes)			
	Nitrogen	6.12**	3.83**	4.52**
	Phosphorus	2.43*	3.37**	4.41**
	Potash	35.72	21.60**	24.81**
	Total	5.23**	3.90**	4.57**
5.	Pesticides (Tonnes)	0.95	-1.98**	-0.54*
6.	Tube well & Pump sets (Nos.)	2.61**	1.33**	1.71**
7.	Tractors (Nos.)	6.01**	3.73**	4.78**
8.	Credit by PACS (Rs in lakh)	26.38**	12.60**	18.69**
9.	Budget on agriculture by govt. (Rs in lakh)	27.78**	1.81	10.49**

Notes: * *Significant at 1% level of significance, * Significant at 5% level of significance

3. 2. Growth Rates in Crop Area

The growth in area of principal crops in the state is shown in Table 2. Wheat and rice the most important crops of the state have a positive growth of 3.20 and 1.70 percent respectively in the last twenty years. This increment in rice and wheat production area was due to increased in irrigated area, availability of fertilizerand HYV, and market security for these crops with provision of Minimum Support Price (MSP) and government procurement. Being less important crops and mostly used for animal feed jowar, bajra, maize and barley cultivation area was decrease. The area under gram and pulses decreased by 10.39 and 8.36 percent respectively due to weather risks, increased irrigation and shifting of cropping pattern to rice -wheat. Positive growth in area observed for oilseeds (1.10%), sugarcane (0.37%) and cotton (0.59%).

Table: 2 Compound Growth Rates of Area under Major Crops in Haryana (Percent/annum)

S.N.	Crops	Growth rates in the period		
		Period -I (1988-89 to 1997-98)	Period -II (1998-99 to 2007-08)	Overall Period (1988-89 to 2007-08)
1.	Rice	4.62**	-0.18	3.20**
2.	Jowar	-0.10	-3.91**	-1.58**
3.	Bajra	-2.26*	0.55	-0.23
4.	Maize	-5.57**	-3.62**	-5.78**
5.	Wheat	1.38**	0.86*	1.70**
6.	Barley	-4.91**	-1.07	-3.54**
7.	Total Cereals	1.16*	0.39	1.49**
8.	Gram	-6.00*	-6.00	-10.39**
9.	Total Pulses	-5.39*	-3.10	-8.36**
10.	Total Food grains	0.24	0.06	0.60**
11.	Total Oilseeds	4.80*	3.37**	1.10
12.	Sugarcane	0.34	-0.15	0.37
13.	Cotton	4.63**	-1.02	0.59

Notes: * *Significant at 1% level of significance, * Significant at 5% level of significance

3.3. Growth Rates in Yield

Table 3 showed the trend in yield of major crops of the state. The yield was positive for rice and wheat and observed 0.83 and 1.11 percent respectively. The yield of bajra, maize and barley were increased by 3.53, 3.95 and 1.92 percent respectively over the years. Jowar was recorded a negative growth of 0.52 and gram of 1.11 percent per annum. There was increase in yield of oilseeds (0.62%), sugarcane (1.22%) and cotton (1.42%) during the overall study period. The increased in yield for most crops was brought about by the introduction of HYVs, use of fertilizers, irrigation etc while the decrease was due to the lack of break through in technology as well as varieties.

Table: 3 Compound Growth Rates of Yield of Major Crops of Haryana (Percent/ annum)

S. No.	Crops	Growth rates in the period		
		Period -I (1988-89 to 1997-98)	Period -II (1998-99 to 2007-08)	Overall Period (1988-89 to 2007-08)
1.	Rice	0.52	4.33**	0.83*
2.	Jowar	-3.35	7.94**	-0.52
3.	Bajra	2.35	5.95*	3.53**
4.	Maize	4.93*	1.48	3.95**
5.	Wheat	1.47**	0.09	1.11**
6.	Barley	4.23**	0.57	1.92**
7.	Gram	2.40	-1.47	-1.11
8.	Total Oilseeds	-0.47	-0.83	0.62
9.	Sugarcane	0.95	2.19**	1.22**
10.	Cotton	-1.82	9.34**	1.40*

Notes: * *Significant at 1% level of significance, * Significant at 5% level of significance

3.4. Growth rates in production

The growth of major crops of the state in terms of production was given table 4. Following the pattern of growth in area and yield the growth in productionwas positive for rice and wheat. Growth rate of 4.06 percent per annum for rice and 2.78 percent per annum for wheat was observed. Bajra production was in positive growth of 3.29 percent per annum. The growth in production was negative for jowar, maize and barley. Gram and total pulses had a negative growth rate of 11.39 and 9.56 percent per annum respectively in production. The production of total oilseeds, sugarcane and cotton had increased by 1.73, 1.48 and 2.0 percent per annum respectively.

Table: 4 Compound Growth Rates of Production of Major Crops in Haryana (Percent/ annum)

S. No.	Crops	Growth rates in the period		
		Period -I (1988-89 to 1997-98)	**Period -II** (1998-99 to 2007-08)	**Overall Period** (1988-89 to 2007-08)
1.	Rice	5.16**	4.15**	4.06**
2.	Jowar	-3.56	4.15*	-2.04*
3.	Bajra	0.03	6.53*	3.29*
4.	Maize	-0.80	-2.21	-2.06**
5.	Wheat	2.87**	0.80	2.78**
6.	Barley	-0.94	-0.49	-1.69*
7.	Total Cereals	2.99**	1.85*	2.98**
8.	Gram	-3.74	-7.40	-11.39**
9.	Total Pulses	-3.24	-3.35	-9.56**
10.	Total Food grains	2.68**	1.76*	2.66**
11.	Total Oilseeds	4.31	2.51	1.73*
12.	Sugarcane	1.19	2.04	1.48**
13.	Cotton	2.72	8.25*	2.00*

Notes: * *Significant at 1% level of significance, * Significant at 5% level of significance

3.5. Impact of Inputs on AGDP

In applying the Cob-Douglas form of production function, the following regression equation was obtained.

$$Y= -21.02\ X_1^{2.36} X_2^{-0.30}\ X_3^{-0.08}\ X_4^{-0.83}\ X_5^{3.94}\ X_6^{-0.03}\ X_7^{-0.33} X_8^{0.02}\ X_9^{0.09}$$

The function showed the significant impact of tubewells and pumpsets while the impact of all other inputs were non-significant. Tubewells and pumpsets had a positive impact on Agricultural Gross Domestic Product (AGDP). The regression result from Cobb-Douglas method showed that irrigation and budget by Haryana government have positive effect on the AGDP. A one unit increased in these inputs increased the AGDP by 2.36 and 0.02 percent respectively.

4. CONCLUSION

The use of all inputs viz. irrigation, area under HYV's, fertilizers, tubewells and pumpsets, credit, tractors and budget allocated on agriculture by government had increased in the state during the study period whereas, the use of pesticideswas decreased. The area under rice, wheat, total cereals, total foodgrains, oilseeds, sugarcane and cotton were increased. The area under jowar, bajra, maize, barley, gram, and pulses was decreased. In case of production rice, wheat , bajra, total cereals, total foodgrains, oilseeds, sugarcane and cotton had positive growth while jowar, barley, gram and pulses showed negative. Similarly rice, wheat, maize, bajra, barley, sugarcane and cotton have recorded an increased in yield but jowar, gram and oilseeds have recorded a decrease. The impact of tubewells and pumpsets on AGDP was significant.

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