DISCUSSION
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The results showed that though location effect was in general non-significant for most of the characters under both sub-tropical and temperate conditions, location x genotypes interactions were significant indicating that genotypes behaved differently at different locations for various characters. Out of eight characters used for genetic divergence studies it was found that under both sub-tropical and temperate conditions, tuber yield was the major contributor (contributing up to 71.6%) to genetic divergence. The other characters which contributed to genetic divergence under both sub-tropical plains and temperate hills were plant height, tuber dry matter, tuber number and number of shoots. However, their total contribution was only 20.6% and 31.1% in sub-tropical plains and temperate hills, respectively. Desai & Jaimini, (1997) reported wide variation for several characters studied and observed clear differences for tuber yield, plant height and average tuber weight which contributed largely to the total divergence. However, per cent contribution by tuber yield was comparatively less (7%) in contrast to the present study. This variation may be attributed to low variability for this character in the material studied by Desai & Jaimini (1997). However, our findings differ from those of Gaur et al., (1978c) and Gopal (1996) who reported that the characters in which no selection pressure was applied during the evolution of present day varieties, are more important to genetic divergence. The reason for this deviation may be because in the present material, nine accessions were of exotic origin and had low yield performance under our growing conditions. This may have resulted in large genetic variability for tuber yield in the present material unlike the material used in the earlier studies and hence tuber yield was the major contributor to genetic divergence.
The clustering pattern was different under the sub-tropical and temperate conditions in which the 17 genotypes were grouped into 8 and 6 clusters, respectively and there was little common with regard to distribution of different genotypes into different clusters under two conditions. This may be attributed to genotype x environment interaction which is known to be important for tuber yield in potato (Sekioka & Lauer, 1970; Metin & Caliskan, 1985; Birhman & Verma, 1986; Dhiman et al., 1986; Gopal, 1989) and tuber yield was the major contributor to genetic divergence in the present study. However, Muziranzara, a neotuberosum derivative (Plaisted, et al. 1987) was in a separate and last group under both the conditions indicating its sharp distinctness from other genotypes which was not affected by complex genotype x environment interactions. Neotuberosum is long day adapted andigena (Glendinning, 1983) and are excellent material for exploitation of heterosis in breeding programmes. The involvement of tuberosum and andigena parents in the crosses would help in exploiting heterosis for tuber yield as has been obtained by many workers (Howard, 1963; Paxman, 1966; Glendinning, 1969; Tarn & Tai, 1973; Tarn, 1975; Cubillos & Plaisted, 1976). A similar result was reported by Pandey & Gupta (1997) who found that andigena genotypes were confined to clusters separate from tuberosum cultures.

The genetic diversity was not related to geographic diversity because genotypes of different countries are grouped together in the same cluster. Similar results were obtained by Gaur et al. (1978c), Singh et al. (1988), Birhman & Kaul (1991), Gopal (1996) and Pandey & Gupta (1997). Though the cluster I was the largest one under both the conditions, the distribution of 17 genotypes into 8 and 6 clusters under two
conditions indicated that the material studied was quite diverse. This may be because the present material was derived from different genetic backgrounds with *tuberosum*, *neotuberosum* and *andigena* in their pedigree.

Cluster I was the largest under both the conditions and is in agreement with previous studies of Birhman & Kaul (1991), Gopal (1996) and Desai & Jaimini (1997). Of the 17 genotypes studied both in sub-tropical plains and temperate hills, 6 and 8 genotypes were grouped together in cluster I. This may be due to their relatively narrow genetic background (Clark, 1925; Hougas & Ross, 1956). The maximum genetic distance was between cluster II and cluster V and the minimum was between cluster VI and cluster VIA under sub-tropical conditions, whereas the maximum genetic distance was between cluster II and VI and minimum between cluster II and IV under the temperate conditions. Lower intra-cluster distances than the inter-cluster ones indicate the homogeneity and heterogeneity within and between clusters, respectively. Since crossing genotypes from the most divergent clusters would result in maximum heterosis, intercrossing the genotypes of distant cluster II and V (EB/A 304, 7XY.1 and Pentland Hawk) under sub-tropical plains is advisable for obtaining heterotic progeny. Whereas, in temperate hills, the parents, HB/82-36, HB/82-372 and HB/83-39 were grouped in cluster II, and the parent Muziranzara in cluster VI. The inter-cluster crossing between these distant genotypes will be useful for exploitation of heterosis.

The choice of parents for a breeding programme constantly puzzles plant breeders. Careful identification of parents is one of the most important components of any breeding strategy. The cultivated autotetraploid potato, *Solanum tuberosum* L.,
is considered an outbreeder species (Mendoza & Haynes, 1974), which suffers from inbreeding depression and also expresses heterosis upon crossing of suitable parents. In evolving high yielding varieties, potato breeders have to deal with quantitative characters which are governed by polygene and show continuous variation. Therefore, to devise most appropriate breeding method to be used for manipulating these genes for the benefit of mankind, it is of paramount importance to have information about the type of gene action involved for a particular trait, the combining ability of parents and their crosses and the estimates of genetic components of variance. The common approach of choosing the parents on the basis of performance and adaptation does not necessarily lead to useful results. This is because of the differential ability of the parents and this ability depends upon the complex interaction amongst genes, which cannot be judged by performance alone (Allard, 1960). The development of quantitative genetics has provided methods which should help to resolve this and other applied problems. Almost all biometrical genetic theory presupposes that inheritance is disomic and that the base population from which parents are to be sampled is either in panmictic equilibrium or consists of inbred lines. The cultivated potato has tetrasomic inheritance and the genetic structure of the populations (collections of vegetatively propagated clones) used as parents by potato breeders is unknown. Conventional biometrical-genetic techniques are, therefore, inapplicable to the crop. However, the use of combining abilities, which are statistical parameters, independent of the genetic status of the crop, offers an alternative approach of considerable potential for the selection of parents and in the formulating of a crossing plan for a plant breeding programme. Information of the relative size of general (GCA) and specific (SCA) combining abilities is also helpful in the analysis and interpretation of
the genetic basic of important traits, such as yield in the autotetraploid potato (Mendoza & Haynes, 1974). The parents which performs well in cross combinations are of great importance to potato breeders. Thus, investigations on general and specific combining ability would yield valuable information, which can be used in various breeding programme.

The work on genetic and combining abilities in potato is not extensive. A perusal of these works revealed the presence of contradictory reports. Further, in most of the studies results were based on a single clonal generation and confined to a few generation (Plaisted et al., 1962; Killick, 1977; Gaur et al., 1983, 1985; Maris, 1989). Tai (1976) had conducted a pooled analysis over three successive clonal generations and reported that interaction of GCA and SCA with years were in general, non-significant, except the GCA x year interaction for average tuber weight, which was highly significant. However, the results of present study, pooled over locations/generations under short days in sub-tropical plains and long days in temperate hills also showed that all characters were effected by locations/generations. Interactions due to lines x locations, testers x locations and lines x testers x locations were significant for a number of characters. Thus, the results indicate the need of conducting combining ability studies over locations/generations.

Besides variation in the performance of genotypes in early clonal generations, performance in seedling generation (TPS crop) is known to be different from that of in the clonal generations of a potato breeding programmes (Anderson & Howard, 1981; Brown et al., 1987a,b; Maris, 1988; Gopal et al., 1992; 1998). So the results of
combining ability analysis are expected to vary for seedling and clonal generations. A comparison of combining ability results of seedling and clonal generations in the present study also reveals the same. Thus, in breeding for commercial cultivation from true potato seed the information about the combining ability effects should be based on the seedling generation itself.

The results showed that SCA was more important than GCA for all the characters in seedling generation. It shows preponderance of non-additive gene action in the inheritance of all the characters viz., plant height, number of shoots, number of leaves, tuber yield, tuber number, average tuber weight and tuber drymatter studied in this generation. The present findings differs from that of Golimirazaie & Mendoza (1985), Gaur et al. (1993) and Pandey (1993) who reported that for tuber yield GCA was more important than SCA in seedling generation, but agrees with that of Dayal (1981), Thompson et al. (1983), Sharma (1987) and Gopal (1998). However, Gaur et al. (1983) had reported that GCA was more important than SCA for average tuber weight and SCA was more important for tuber number in the seedling generation. On the other hand, Sharma (1987) opined that GCA was more important for number of tubers and SCA for average tuber weight.

In clonal generation also, SCA variance was more important than GCA for majority of characters studied at both the locations/generations. Preponderance of SCA variance in clonal generation for tuber yield, tuber number and average tuber weight was reported by Plaisted et al. (1962), Tai (1976), Killick (1977), Gaur et al. (1985) and Gopal (1998). Amalraj & Rao (1994) found both non-additive as well as additive
types of gene action for all traits studied, of which non-additive type of gene action
was predominant. Mullin & Lauer (1966), Veilleux & Lauer (1981), Gaur et al. (1983)
and Neele et al. (1991) also reported that both GCA and SCA were equally important
for tuber yield. However, in the present study GCA was more important than SCA for
number of leaves and number of nodes in first clonal generation at Modipuram and
Jalandhar. In temperate hills, GCA was more important for number of leaves, number
of nodes and tuber dry matter in first clonal generation and for number of shoots in
second clonal generation. In pooled analysis, GCA was more important for number of
shoots and tuber dry matter in sub-tropical plains. In pooled analysis over generation,
GCA was important for plant height in temperate hills. However, number of leaves
and number of shoots in pooled analysis over locations in sub-tropical plains, both
GCA and SCA were found to be equally important. The above comparisons show that
relative importance of SCA and GCA varied with the character, generation, location,
as well as with the worker. This in fact may be due to the type of material,
experimental design and environmental conditions under which the material was
studied. These findings are in accord with the work of Maris, (1989) who also reported
the same.

Bradshaw & Mackay (1994), while reviewing the role of combining ability effects
in identifying superior parents in potato breeding programmes, concluded that both
general and specific combining ability effects contribute to the genetic variation
observed in a population. The present findings confirm this, although the estimates of
variance due to SCAs were found to be more important than GCAs for various
characters. Plaisted et al. (1962) stated that larger estimates of SCA variance than
the corresponding GCA may be a characteristic of tetraploid potatoes; and further opined that informal previous selection which narrowed the genetic base of the tested genotypes may be the possible causes for obtaining greater estimates of SCA variance for various characters. The present study endorses this concept as many of the genotypes used in it had been subjected to selection for tuber yield and other characters under various breeding programmes. Killick & Malcolmson (1973), using a concept developed in evolutionary population genetics, suggested that traits subjected to directional selection would be expected to show little additive genetic variance, but a large degree of dominance and epistasis, whereas the reverse would be true for traits subjected to stabilising selection. The characters under study in the present investigation were undoubtedly subject to directional selection, as high performance for them is a major goal of any potato breeding programme. So a preponderance of SCA variance over GCA for most of the characters, as observed in the present study, was expected.

Though SCAs were more important than GCAs, both GCA and SCA effects were significant for number of the characters in all the locations/generations. So estimates of GCAs would be useful in identifying parents with high breeding values. Estimation of SCAs would be useful in identifying the crosses whose performance deviated significantly from that expected on the basis of GCAs of the parents involved. The genotypes used in the present study are frequently involved in various Indian potato breeding programmes. The information about their general combining ability effects is, therefore, of interest to the potato breeders. Hence, a fixed effect model was used for considering the set of parents as a complete population.
The good general combiners in seedling and clonal generations varied. When all characters of major importance such as tuber yield, tuber number and average tuber weight were considered, parents HB/82-36, JEX/C-166, AL-624 and K.Megha were good combiners in the seedling generation, thereby, indicating that these parents were suitable for TPS crop. Among these good parents, K. Megha was a good combiner for flowering intensity, duration of flowering, plant maturity and pollen fertility. This parent could be exploited for developing early maturing TPS populations. Whereas, parents EB/A-304 and I-1039 were suitable for tuber crop and JEX/C-166 was suitable for both TPS and tuber crop. The parents, Tollocan and Goya were found to be poor combiners in all generations/locations.

Under temperate conditions in the hills, the good combiners differed mostly from that of the sub-tropical conditions in the plains for characters of major economic importance. The parents, HB/82-372, I-1039, EB/A-304, Tollocan and AL-624 were good combiners in both the generations under temperate conditions and these could be exploited in the breeding programmes for development of cultivars for hilly regions of the country. The poor combiners varied in both the generations, and on the basis of pooled analysis, the parents HB/82-36, JEX/C-166, 7XY.1, JH 214 and LT-5 were found to be poor combiners. The parents, EB/A-304 and I-1039 which were good combiners both in hills and plains are suitable for exploitation both under long and short day conditions.

Disease control is a prerequisite for improving yield and quality of potato (Birhman et al., 1992) crop since the Irish blight epidemic of 1840. Based on the AUDPC values,
the parents, HB/83-39, Muziranzara, EB/A-304, Pentland Hawk and Kufri Megha were found to be good general combiners capable of transmitting late blight resistance into progeny in both the generations. These good combiners were of immense value for their exploitation in the breeding programmes where resistance to late blight is a must for cultivars. The parents Kufri Jyoti and JH 214 were poor combiners in both the generations.

Flowering intensity, days to flowering, duration of flowering and pollen fertility are important traits identifying value of parents/crosses for TPS production. The study has shown that parents, Goya, HB/83-39 and K.Jyoti were good combiners for flowering intensity and AL-624, Muziranzara, K.Megha and I-1039 were good combiners for duration of flowering, and POOS.16, Kufri Megha and Tollocan were good combiners for both the characters. These parents are of practical value in breeding for the exploitation of flowering intensity and duration of flowering in the hybrid seed production programme. Very often the TPS production is restricted due to poor flowering and short duration of the flowering period of parents. These good combiners could be utilized in the commercial production of TPS for raising the TPS crop. EB/A-304 was a good combiner for days to flowering, whereas, parents HB/82-36, HB/82-372 and EB/A-304 were poor combiners for flowering intensity; Goya, 7XY.1, EB/A-304 and JEX/C-166 were poor combiners for duration of flowering; and HB/82-36, JH 214 and K.Jyoti were poor combiners for days to flowering. For pollen fertility, the parents Muziranzara, POOS.16, HB/82-36, HB/82-372, K.Megha and 7XY.1 were good combiners and Pentland Hawk, EB/A-304, K.Jyoti and I-1039 were poor combiners. Moreover, the parents, Goya, Pentland Hawk, AL-624, POOS.16 and K.Jyoti were
good combiners for plant maturity. Some of the good combiners for both total protein and total sugar were Muziranzara and POOS.16, whereas, Pentland Hawk and JH 214 were poor combiners for both the characters.

Specific combining ability variation composed of dominance and dominance type epistatic components (Bradshaw & Mackay, 1994). In diploid crops only the additive effects are heritable, some epistatic effects persist as long as selection pressure is made to favour certain mating types. In asexually propagated tetraploid crop like potato, all types of gene effects are heritable from one to other clonal generation (Gcpal, 1996).

In seedling generation, the cross with highest SCA for tuber yield involved both parents with medium GCAs. Among the next four top crosses, two involved one parent with average GCAs and two had both parents with low GCAs. Based on pooled analysis over locations in sub-tropical plains five top crosses with significant positive SCAs for tuber yield were identified; these are AL-624 x Tollocan, Goya x JEX/C-166, Pentland Hawk x I-1039, HB/82-372 x 7XY.1 and EB/A-304 x JEX/C-166. Of the five top crosses with high SCAs, two involved parents with high x high GCAs; one with medium x medium GCAs and one each with high x low and low x high GCAs. In pooled analysis over generations under temperate hills, five top crosses with significant positive SCA's were AL-624 x Tollocan, HB/83-39 x I-1039, K.Jyoti x Tollocan, Muziranzara x LT-5 and Pentland Hawk x JEX/C-166. In this case three top crosses with top SCAs involved parents with medium x high GCAs and one each with average x medium and low x low GCAs. Likewise, the same pattern was observed for
tuber number and average tuber weight. There did not appear to be any relationship between the GCA effects of the parents and SCA effects of the crosses for various characters studied indicating that selection of parents on the basis of general combining ability will not limit the exploitation of SCA effects for improvement of tuber yield and its components. A similar conclusion was also arrived at by Plaisted et al. (1962) and Gaur et al. (1993). So far as the other traits are concerned, the present observations showed that the high SCA effects can be realized irrespective of the GCA values of the parents involved. This findings differs with that of Gaur et al. (1983) who reported that for high tuber yield one parent should invariably be a good combiner. In another study, Gaur et al. (1985) however, stated that crosses with high SCA effects involved parents with average combining ability for tuber yield. Our results showed that for all characters studied, all types of epistatic interaction, i.e., additive x additive, additive x dominance and dominance x dominance were important depending upon the genotype of the parents involved. High SCA effects in crosses involving both parents with low GCA effects, may be due to preponderance of complimentary gene action in these cross combinations.

The mean squares due to parents vs hybrids were significant for all characters both under short days in sub-tropical plains and under long days in temperate hills indicating the presence of heterosis for all of them. Heterosis over mid parents was positive in a number of crosses for all the characters studied in sub-tropical plains, whereas under temperate hills most of the crosses had negative heterosis for these characters. For example, under sub-tropical short day conditions 52 crosses had positive heterosis for tuber yield, and only 8 had negative heterosis, whereas under
temperate long day conditions in hill, only 9 crosses had positive heterosis and 44 had negative heterosis for this character. This trend was observed both for pooled analysis as well as individual analysis. Negative heterotic effects for tuber yield and its components within *Tuberosum* crosses under temperate conditions, as observed in the present study, agrees with previous studies as reported by Maris (1969), Tai (1974) and Tarn & Tai (1983). This is attributed to the relatively narrow genetic of the *Tuberosum* group (Mendoza & Haynes, 1974). Probably hybrid progenies involving varying taxonomic groups (Tarn & Tai, 1977, 1983) may be required for realization of positive heterosis under temperate long day growing conditions. Poor performance of progenies as compared to parents for foliage character like size and lateness (present study) indicated that progenies were slow growing (late) as compared to the parents (Maris, 1969; Tai, 1974). Further, Tarn & Tai (1983) had also reported that, in general, progenies are late maturing than the parents. Presently, the slower growth of progenies may also be due to the fact that the seed tubers used were of comparatively smaller size in the progenies than that of parents. Moreover, when dehaulming was done, the crop was comparatively immature under long days in hills than those under short days in plains. Keeping in view the general cultural practices of these regions, the dehaulming was done at 90 and 120 days under short and long days, respectively. Further, short days are known to be conducive for tuber initiation and rapid bulking (Pushkarnath, 1976; Ross, 1986). This may be the reason for better heterosis observed for tuber yield and its components under short days as compared to long days in the present study. The 120 days crop allowed under temperate conditions may not be sufficient to realize full potential of the progenies tested.
In sub-tropical plains the best heterotic cross for tuber yield was AL-624 x Tollocan which has given heterosis in both the locations and also in pooled analysis over locations. This cross should be exploited for breeding programmes aimed at developing varieties with higher yield. Under temperate hills, three crosses viz., Muziranzara x LT-5, K.Megha x Tollocan and K. Jyoti x Tollocan which gave heterotic progenies in both the generations and also in pooled analysis over generations. These crosses/parents are excellent material for utilization in breeding programmes aimed at developing high yielding varieties in temperate hill regions. The cross AL-624 x Tollocan gave heterotic progenies both in plains and hills and could be exploited for developing varieties with wide adaptability.

The general combining ability effects of the parents involved in various crosses showed that most of the crosses with positive heterosis for tuber yield and its components had at least one parent with good general combining ability both under short and long days and in pooled as well as individual locations/generations. On the other hand, the most of the crosses with negative heterosis involved parents with poor combining ability. For example, of 52 crosses with positive heterosis for tuber yield in pooled analysis under short days, 36 involved at least one parent with good general combining ability. Similarly, out of 44 crosses with negative heterosis for tuber yield in pooled analysis in long day conditions, 31 involved both or at least one parent with poor combining ability. Similar trend was observed for characters, plant height, number of shoots, leaves and nodes, and tuber dry matter. This shows the importance of additive component of variance for realizing heterosis for these characters.
Among characters which were recorded only under long day conditions, this pattern was observed for area under disease progress curve (AUDPC), total protein and to some extent for total sugar. However, for characters like flowering intensity, days to flowering, duration of flowering and plant maturity, general combining ability effects of the parents were not associated with the heterosis of the crosses involving these parents. For example, out of 23 crosses with positive heterosis, for plant maturity in the present materials only 8 crosses had parents with good general combining ability. This shows that for realizing heterosis for these characters, specific gene combinations (non-additive gene action) are more important.

In potato, tuber yield is most important economic trait. Therefore, information on the heterotic effect of parent/cross is of interest in a systematic breeding programme. Exploitation of positive heterosis is by far the most satisfactory method of potato breeding aimed to enhance tuber yield. This is because the heterotic seedling can be easily maintained with all its intra-and inter-locus interactions, and can be quickly multiplied and released as a new variety. But for high positive heterosis recovery in tuber yield, crosses between closely related parents provide little or no positive heterosis (Ross, 1986). Therefore, for effective increase in tuber yield, hybrids from genetically distant and divergent parents have to be obtained. This calls for the determination of genetic divergence and distance in the available potato material before the parents are selected for use in a crossing programme. Heterosis over mid-parent was observed in a number of crosses in the genotypes studied. Pandey & Gupta, (1995) and Desai & Jaimini (1997) opined that genetic divergence is related to heterosis. In practical situations, it can be reasoned that heterosis occurs because
of parental divergence, but when divergent parents are crossed, heterosis is not found to occur always (Cress, 1966). Presently, out of 52 crosses which showed positive heterosis for tuber yield under sub-tropical plains, 43 crosses involved parents from different groups and 9 crosses involved parents from same group, whereas out of 8 crosses with negative heterosis, 5 involved parents from different group and 3 from the same group. Further, the best heterotic cross AL-624 x Tollocan had both the parents from the same group in study conducted under short day conditions. This also holds true for best heterotic cross Kufri Jyoti x Tollocan for tuber yield under long days. It is essential, therefore, to explore the possible limits to parental divergence within which there are reasonably high chances for occurrence of heterosis (Arunachalam & Bandyopadhyay, 1984). Tuber yielding ability and response to environmental changes are two independent attributes of a genotype governed by separate sets of gene systems (Birhman & Kaul, 1991). Therefore, selection of genotypes which are iso-responsive is essential for use in breeding. For obtaining high yielding hybrids that exhibit heterosis for yield, crossing among the divergent varieties even those from one cluster has been recommended earlier by Singh (1988). However, in the present study only moderate relationship has been obtained between heterosis and genetic divergence, as also reported earlier by Gopal & Minocha (1997). Furthermore, due to extensive cultivation and rigorous selection, the genetic variability in this crop is reduced (Nayar, 1986; Ross, 1986; Birhman et al., 1988; Hosaka & Hanneman, 1988), nevertheless the grouping pattern of the parents used in the present study shows that 6 parents are grouped only in I group in short days and 8 parents in I groups in long days. The observed genetic diversity in the material presently studied may not be sufficient for predicting heterosis. Probably genetic
divergence involving varying taxonomic groups (Tarn & Tai, 1977, 1983) may be required for cross prediction.

In general, genotypic correlation coefficients were slightly higher than the corresponding phenotypic correlation coefficients. This suggests that environmental variation adversely affected the association. Due to this in some cases though genotypic correlation coefficients were significant, phenotypic ones were non-significant. The magnitude of correlations varied from location to location and generation to generation. This may be attributed to genotype x environment interactions at different stages of development.

Tuber yield showed positive association with average tuber weight under both subtropical plains and temperate hills in individual and in pooled analysis. The magnitude varied from moderate to high ($r_p=0.59 - 0.88; \ r_g= 0.52 - 0.96$). The association found between tuber yield and average tuber weight in the present study is in agreement with previous reports of Maris (1969), Gaur et al. (1978), Sidhu & Pandita (1979), Singh et al. (1979), Birhman & Verma (1986) and Gopal et al. (1994a,b). Tuber yield was positively associated with tuber number ($r_p= 0.57 - 0.83; \ r_g= 0.52 - 0.87$) in individual and in pooled analysis under temperate hills. Similar associations between tuber yield and tuber number were reported by Sidhu & Pandita (1979), Pandita & Sidhu (1981) and Birhman & Verma (1986). However, in sub-tropical conditions this association was significant only in first clonal generation at Jalandhar. Moreover, no association was observed between tuber number and average tuber weight. The present study clearly indicates the possibility to use average tuber weight and tuber
number as component traits of tuber yield for selection of tuber yield under varying environments extending from temperate to sub-tropical conditions. Therefore, it is necessary for a plant breeder engaged in improvement of tuber yield, to lay emphasis on simultaneous selection for tuber number and average tuber weight for improving tuber yield.

The other significant association were between plant height and number of leaves and plant height and number of nodes both under sub-tropical plains and temperate hills. This agrees with the reports of Dayal et al. (1972) and Sidhu & Pandita (1979) who also reported a positive association between tuber yield and plant height in clonally propagated tuber material.

Among the seven additional characters studied only in first clonal generation in temperate hill, tuber dry matter was positively associated with plant maturity. This confirms the earlier reports that tuber dry matter increases during later stages of potato growth (Misra et al., 1993). In the present study parents with medium maturity (Goya, Pentland Hawk, AL-624, POOS.16, HB/82-372, K.Jyoti, I-1039, 7XY.1, JEX/C-166) had less dry matter than the late maturing genotypes (Muziranzara, EB/A-304, JH 214, HB/82-36, HB/83-39, K.Megha, Tollocan, LT-5). A positive association between plant maturity and duration of flowering and duration of flowering and flowering intensity was also observed. It is in agreement with the reports of Gopal, (1994) who reported a positive association between flowering intensity and duration of flowering in *tuberosum* germplasm. It also shows that selection of profuse flowering genotypes may result in late maturing progenies. Where the objective is to breed early
maturing varieties, some compromise will have to be made on the flowering intensity of parents to be used in hybridization programme. A negative association was, however, observed between flowering intensity and AUDPC. This was expected because only the late blight resistant genotypes survived during the later stages of crop in hills where the susceptible ones die prematurely. Tuber dry matter and AUDPC were negatively associated in second clonal generation and in pooled analysis over generations. This may be because the genotypes with high AUDPC died earlier and have got less time for accumulation of tuber dry matter. Other negative associations were, plant height and average tuber weight; plant height and AUDPC; plant height and number of shoots and average tuber weight in pooled analysis over generations under temperate hills. The above correlation studies shows that for tuber yield morphological characters are not important, but plant height, number of shoots adversely affect average tuber weight.

The values of coefficient of variation (both phenotypic and genotypic) were high (25.25-34.79) for number of shoots, tuber yield and average tuber weight both under short and long days in individual as well in pooled analysis, indicating the presence of sufficient variability for these characters for selection to be practised. On the other hand, number of leaves, number of nodes and tuber dry matter had low coefficient of variation. As expected, estimates of phenotypic coefficient of variation (PCV) which includes the coefficient of variation (CV) due to environment was higher than genotypic coefficient of variation (GCV) for all the characters.
As reported by Dayal et al. (1972), Gaur et al. (1978b), Metin & Caliskan (1985), Desai & Jaimini (1997) and Birhman & Kaul (1989), the present study shows high estimates of heritability (> 0.80 - 0.89) for plant height, tuber yield and average tuber weight in pooled and in individual analysis for both short and long days. Thus these characters are expected to respond more favourably to selection. Further, the heritability was low for number of shoots, number of leaves and number of nodes (0.245 - 0.546) in pooled and as well in individual analysis both under short and long days, whereas remaining characters exhibit moderate heritability (0.668-0.752).

Likewise, low heritability for tuber yield was reported by Dayal et al. (1972), Sawant & Mandloi (1974), Sidhu & Pandita (1979), Birhman et al. (1984, 1989). These variations in results of various studies may be due to the reason that genetic parameters are not properties of a specific trait but also of the population and the environmental circumstances to which the individuals are subjected (Falconer, 1987).

The characters with high heritability and high coefficient of variation, as expected, had high genetic advance. However, tuber dry matter though had high heritability, had low genetic advance, because of their low phenotypic variation.

Among the characters studied only under long days the coefficient of variation was high (47.11-55.35) for AUDPC and total sugar; moderate (19.59-30.61) for plant maturity, flowering intensity, duration of flowering and total protein and low (10.88) for days to flowering. Heritability was high for most of the characters (0.840-0.980) and these also exhibited high genetic advance. The high heritability and low estimates of genetic advance however, was observed for plant maturity, total protein and total sugar. This indicated the difficulty of improving these characters. Johnson et al. (1955)
and Lerner (1958) had also reported that heritability along with genetic advance is a more reliable criterion than the former one alone in predicting the effect of selection.